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A KEY TO THE GENERA OF ANISOPTEROUS DRAGONFLY NYMPHS OF THE UNITED STATES AND CANADA (ODONATA, SUBORDER ANISOPTERA)

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Since the publication of "A Handbook of the Dragonflies of North America" by Needham and Heywood in 1929, much additional information concerning the immature stages has been accumulated and nymphs of a number of previously unknown genera and species have been described. Several students of the Odonata (Byers, 1936, and Needham and Fisher, 1936), have published revised keys to certain families or subfamilies, but no comprehensive key to the order as a whole has as yet appeared. This paper covers all of the genera of Anisopterous dragonflies known from North America north of Mexico. Keys are presented for the identification of the genera and a list of available literature for specific identification is appended. A glossary of all terms used and illustrations of the majority of the structures of nymphs are included. It is suggested that the beginning student study closely figures E and F of Plate 1, figures L and N of Plate 3, figure G of Plate 4, and figure J of Plate 5 before attempting to use the keys. In these figures are illustrated most of the structures used in the generic identification of Odonata nymphs.

The senior author is responsible for the greater portion of the taxonomic part of this paper, while the junior author has contributed the many illustrations and has helped on the other portions. It was intended at first to present keys to the whole order, but due to our lack of material in certain genera and to the extreme uniformity of the genera of the *Coenagrionidae*, we have decided to delay publication of the section on *Zygoptera* until more material and time for study are available.

It is our hope that these keys will be useful particularly to students of aquatic biology and to those engaged in the study of foods of fish and aquatic birds. We are grateful for the constructive criticism coming from the many students in various entomological classes and to the workers in food analysis who have used this key. We are particularly indebted to Dr. E. M. Walker for his examination and much constructive criticism of this manuscript. Thanks are due to the University of Michigan Museum of Zoology for the loan of much material used in the preparation of these keys. Any criticisms or corrections from students using these keys will be gratefully received by the authors.

The following key is most successful with late instar nymphs. Also nymphs killed and preserved in 95 per cent ethyl alcohol have proven to be more satisfactory for examination and identification than specimens killed or preserved in some other manner.

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Keys to Genera for Nymphs of Anisoptera (Odonata) of the United States and Canada

KEY TO SUB-ORDERS AND FAMILIES OF THE ODONATA

1. External gills present in the form of three flat triangular vertical plates at end of abdomen; head wider than thorax and abdomen (6A) ..... Suborder ZYGOPTERA. 2
   External gills absent; head not wider than abdomen and thorax (1A), ... Suborder ANISOPTERA. 4
2. First antennal (6E) segment as long as the six succeeding segments together; mentum with a deep and open median cleft (6D) ..... AGRIONIDAE
   Antennal segments all of approximately the same size (6A); mentum entire or with a closed median cleft (6F) 3
3. Mentum with a median closed cleft; the mentum spoon shaped, its base reaching to meso-thoracic coxae or beyond (6B) ..... LESTIDAE
   Mentum entire, without a median cleft; mentum flat, not spoon shaped, its base not reaching much beyond prothoracic coxae (6C) ..... COENAGRIONIDAE
4. Labium flat, or nearly so; without stout setae on the mentum (3P) 5
   Labium spoon-shaped, covering the face to the base of the antennae (1F); mentum armed with stout setae (3L) 7
5. Antennae 4-segmented (3 C, D, E); pro and metatarsi with but 2 segments (1A), ... GOMPHIDAE
   Antennae 6- or 7-segmented (3 A, B); all tarsi with 3 segments (with the exception of *Gomphaeschna* in which the fore tarsi have but 2 segments) 6
6. Antennal segments short, thick, and heavily setiferous (3B); a pair of latero-dorsal tufts of long black bristles on abdominal segments 2 or 3 to 9 (4K) ..... PETALURIDAE
   Antennal joints slender and bristle-like (3A); no latero-dorsal abdominal hair tufts present, ... AESHNIDAE
7. Distal edge of lateral lobe with large, irregular teeth (3H); mentum with a median cleft, ... CORDULEGASTERIDAE
   Distal edge of lateral lobe entire, or with small, even-sized crenulations or teeth (3I); mentum lacking a median cleft ..... LIBELLULIDAE

Family Petaluridae

There are but two genera of this family known from the United States and each is represented by but a single species. Only the nymph of the eastern species is at present known.

The species are: *Tanypteryx hageni* Selys (western) and *Tachopteryx thoreyi* Hagen (eastern).

Family Gomphidae

Key to Genera

1. Tenth abdominal segment nearly as long as all other abdominal segments combined (4 E), ... **Gomphoides williamsoni**
   Tenth abdominal segment shorter than eighth and ninth abdominal segments combined (4 A–D) 2
2. Mesocoxae closer together at base than procoxae (4 I); fourth antennal segment elongate, as long as first antennal segment (3 E) ..... **Progomphus**
   Procoxae and mesocoxae approximately same distance apart at their bases (4 J); fourth antennal segment never as above, usually a small rounded knob (3 C, D) 3
3. Wing cases divergent not parallel with meson (1 C) 4
   Wing cases parallel with meson (1 A) 5
4. Dorsal hooks present on abdominal segments 2 or 3 to 9; those on the caudal segments being hook-like and curved dorsad ..... **Ophiogomphus**
   Dorsal hooks present only on abdominal segments 2 to 4; segments 8 and 9 may have a slight thickening on the mid-dorsal line, but these are never as described above, ... **Erpetogomphus**

Explanation of Plate 1

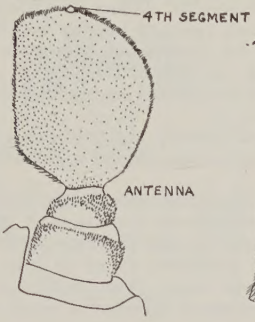
ANISOPTERA

A. Dorsal view of *Hagenius*.
B. Antenna of *Hagenius*.
C. Dorsal view of *Ophigomphus*.
D. Antenna of *Lanthus*.
E. Dorsal view of *Epicordulia*.
F. Lateral view of *Epicordulia*.

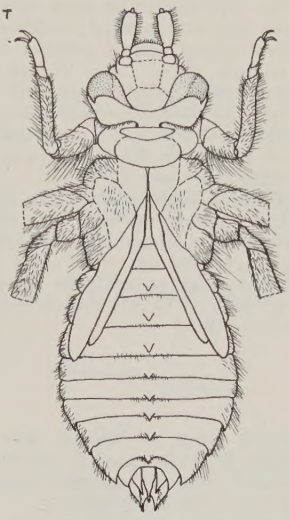
ODONATA – ANISOPTERA PLATE I.

NYMPHS AND ANTENNAE

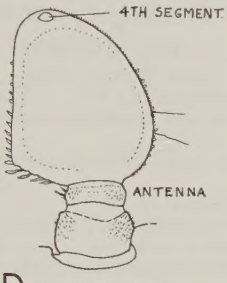
A. HAGENIUS
DORSAL VIEW



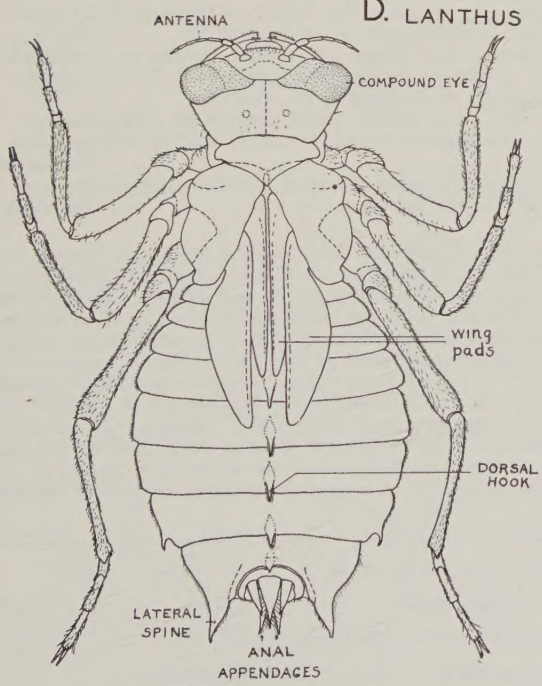
B. HAGENIUS



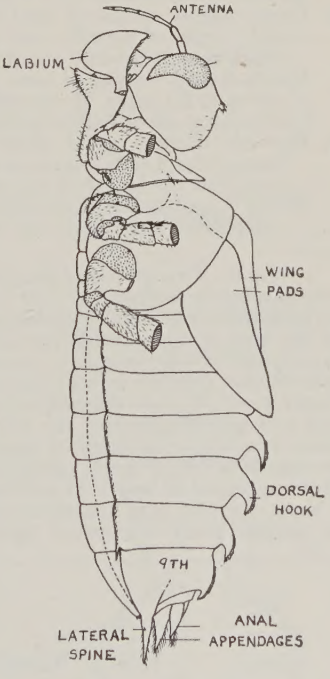
C. OPHIOGOMPHUS
DORSAL VIEW



D. LANTHUS



E. EPICORDULIA
DORSAL VIEW



F. EPICORDULIA
LATERAL VIEW

5. Third antennal segment thin, flat, and suboval (1 B, D)....6
   Third antennal segment elongate or linear, usually cylindrical (3 C)....8
6. Body depressed; abdomen subcircular, almost as wide as long (1 A)....**Hagenius**
   Body not so depressed; abdomen twice as long as wide (1 C)....7
7. Short lateral spines present on abdominal segments 7 to 9; third antenna, segment narrow, about twice as long as wide (3 D)....**Octogomphus**
   Short lateral spines present on abdominal segments 8 and 9; third antennal segment wide, fully as wide as long (1 D)....**Lanthus**
8. Abdominal segment 9 rounded dorsally and without a sharp apical spine (=dorsal hook); or, if a dorsal hook is present on abdominal segment 9, then the segment is longer than wide at its base (4 C, D)....**Gomphus**
   Abdominal segment 9 with an acute mid-dorsal ridge with a spine (=dorsal hook) at its apex; this segment never as long as wide at its base (4 A, B)....9
9. Lateral anal appendages as long as the superior appendage; fourth antennal segment a conspicuous upturned conic rudiment about as long as the second segment..**Gomphoides**
   Lateral anal appendages never more than three-fourths the length of the superior appendage (4 A); fourth antennal segment a small round structure, not as described above (3 C)....**Dromogomphus**

Family Aeshnidae

Key to Genera

1. Lateral lobes of labium with stout lateral setae....**Gynacantha, Triacanthagyna**
   Lateral lobes lacking any lateral setae (3 O, P)....2
2. Protarsi with 2 segments, meso and metatarsi with 3 segments....**Gomphaeschna**
   All tarsi with 3 segments....3
3. Distal border of mentum with a pair of sharp, parallel spines, one on each side of the mental cleft (3 O)....**Coryphaeschna**
   Distal border of mentum not so armed (3 P)....4
4. Lateral spines present on abdominal segment 7 to 9, (*see Note 2*)....**Anax**
   Lateral spines present on abdominal segments 4, 5 or 6 to 9....5
5. Caudo-lateral margin of head from dorsal view with two large, well-developed tubercles (2 L); apex of superior anal appendage truncate or but feebly emarginate (4 H); eyes small, occupying only one-third of the lateral margin of the head (2 L)....6
   Caudo-lateral margin of head from dorsal view never with two tubercles as described above (2 K); apex of superior anal appendage deeply emarginate (4 F, G); eyes large, occupying about half of the lateral margin of the head (2 K)....7
6. Low but distinct dorsal hooks (best seen from lateral view) present on abdominal segments 7 to 9 (4 H); apex of lateral lobe broadly rounded; lateral anal appendages less than half the length of the superior....**Nasiaechna**
   Dorsal hooks absent on all abdominal segments; apex of lateral lobe truncate; lateral anal appendages more than half the length of the superior....**Epiaeschna**

Note 2. Two species of the genus *Aeshna* (*A. caerulea* Burm. and *A. sitchensis* Hagen) have lateral spines on segments 7 to 9 only. They would thus key out to Anax. Calvert (1934) reports an occasional individual of *Anax junius* with small lateral spines on segment 6. The larger size of the Anax nymphs should be indicative, but the following characters are useful when in doubt (applicable to fully or nearly grown individuals). *Anax*—superior anal appendage but slightly shorter than inferior; inferiors about one and one-half times as long as mid-dorsal length of segments 9 and 10; male appendate (on dorsum of superior appendage) truncate or concave at apex and half or less than half the length of the lateral appendages; ovipositor (in *A. junius*) only about two-thirds the length of segment 9, not reaching hind margin of 9. *Aeshna*—(lateral spines on segments 7 to 9 only); superior appendage about one-fourth shorter than inferiors; inferiors about subequal in length to mid-dorsum of segments 9 and 10; male appendage triangular with a blunt, rounded apex and about three-fourths as long as lateral appendages; ovipositor reaching to proximal third or fourth of segment 10.

Explanation of Plate 2

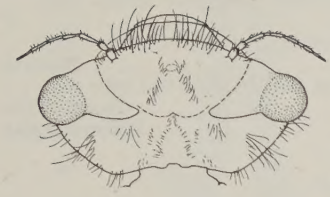
ANISOPTERA

Heads, all dorsal views except figure N.

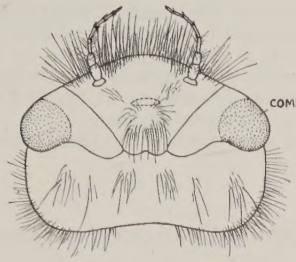
A. *Libellula.*
B. *Plathemis.*
C. *Paltothemis.*
D. *Somatochlora.*
E. *Platycordulia.*
F. *Neurocordulia.*
G. *Tramea.*
H. *Pachydiplax.*
I. *Leucorrhinia.*
J. *Celithemis.*
K. *Basiaeschna.*
L. *Nasiaeschna.*
M. *Macromia.*
N. *Macromia,* lateral view.
O. *Octogomphus.*

ODONATA – ANISOPTERA PLATE 2.

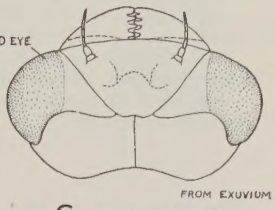
HEADS – DORSAL



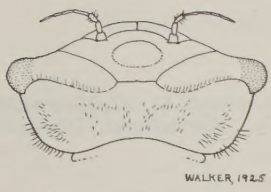
A. LIBELLULA



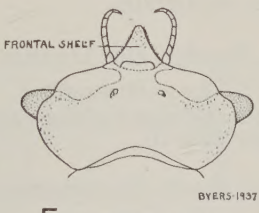
B. PLATHEMIS



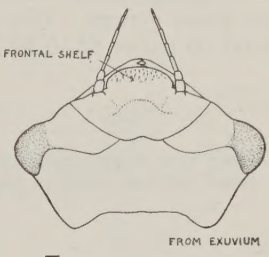
C. PALTOTHEMIS



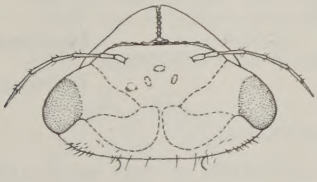
D. SOMATOCHLORA



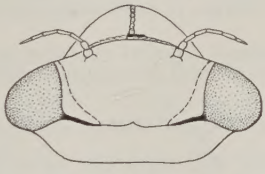
E. PLATYCORDULIA



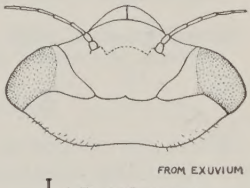
F. NEUROCORDULIA



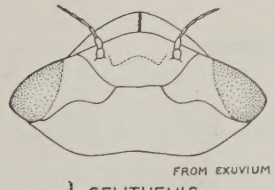
G. TRAMEA



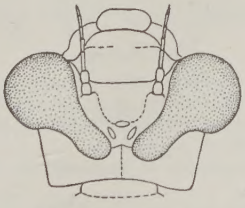
H. PACHYDIPLAX



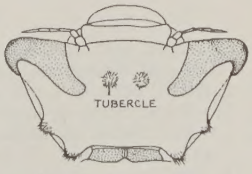
I. LEUCORRHINIA



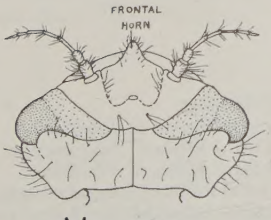
J. CELITHEMIS



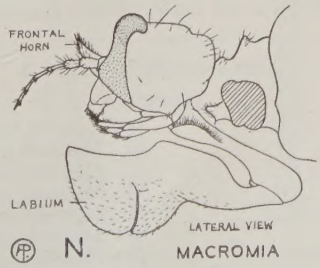
K. BASIAESCHNA



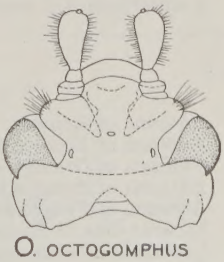
L. NASIAESCHNA



M. MACROMIA



(P) N. MACROMIA



O. OCTOGOMPHUS

7. Lateral spines present on abdominal segments 6 to 9; if there is a small spine on segment 5 then the caudo-lateral margin of the head is rounded and the lateral anal appendages one-half or greater than one-half the length of the inferiors (*see Note 2*).....**Aeshna**
Lateral spines present on abdominal segments 4 or 5 to 9; caudo-lateral margins of the head distinctly angulate, or, if obtusely angulate or rounded, then the lateral anal appendages are but one-fourth the length of the inferiors.....7
8. Lateral lobe of labium obtuse or subtruncate at tip (3 F); median border of lateral lobe with distinct, more or less square-cut teeth.....**Boyeria**
Lateral lobe of labium with a taper pointed tip (3 G); median border of lateral lobe with indistinct denticulation.....**Basiaeschna**
9. Nymphs unknown.....**Oplonaeschna**

Family Cordulaegasteridae

The majority of the papers found in the literature include all species of this group found in our fauna in one genus, Cordulaegaster. Byers (1930), however, lists three genera. His discussion of this family is worthy of note and is to be found on pages 82 to 89 in his monograph.

Family Libellulidae

Key to Subfamilies

1. Head with a prominent frontal horn between the bases of the antennae (2 M, N), **Macromiinae**
2. Head without such a projection (2 A, D).....**Corduliinae, Libellulinae**

Subfamily Macromiinae

Key to Genera

1. Lateral spines of ninth abdominal segment reaching less than half way to apex of anal appendages (5 A); cephalic margin of head noticeably wider than caudal margin (2 M), **Macromia**
Lateral spines of ninth abdominal segment reaching to apex of anal appendages (5 B); cephalic and caudal margins of head subequal in width.....**Didymops**

Subfamilies Corduliinae and Libellulinae

There are no points which will separate all of the members of one subfamily from all of the members of the other subfamily, hence the genera are keyed out together. In compiling this key liberal use has been made of many sources, the most important among them being Byers (1936) and Needham (1936).

Key to Genera

1. Abdomen with dorsal hooks or knobs present on one or more segments.....2
Abdomen with dorsal hooks or knobs absent on all segments.....21
2. A dorsal hook or knob present on abdominal segment 9.....3
No dorsal hook or knob present on segment 9.....12
3. Lateral spines of abdominal segment 9 reaching to or beyond the tips of the anal appendages (1 E, F; 5 C).....4
Lateral spines of segment 9 short, not reaching to tip of anal appendages (5 E–H).....7
4. Lateral spines of segment 8 set at an angle to the long axis of the abdomen, not parallel to those of segment 9 (5 C, D).....5
Lateral spines of segment 8 not at an angle, usually parallel to those of segment 9 (1 E)...6

Explanation of Plate 3

ANISOPTERA

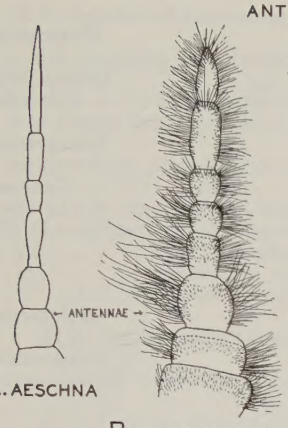
A. Antenna of *Aeschna.*
B. Antenna of *Tachopteryx.*
C. Antenna of *Dromogomphus.*
D. Antenna of *Octogomphus.*
E. Antenna of *Progomphus.*
F. Lateral lobe of *Boyeria.*
G. Lateral lobe of *Basiaeschna.*
H. Lateral lobe of *Cordulegaster.*
I. Lateral lobe of *Pantala.*
J. Lateral lobe of *Tramea.*
K. Mentum and lateral lobes of *Libellula.*
L. Mentum and lateral lobes of *Epicordulia.*
M. Mentum and lateral lobes of *Plathemis.*
N. Mentum and lateral lobes of *Dromogomphus.*
O. Mentum and lateral lobes of *Coryphaeschna.*
P. Mentum and lateral lobes of *Aeschna.*
Q. Antenna of *Pachydiplex.*

Figures K to P show dorsal surface (inner surface of mentum when labium is at rest).

ODONATA – ANISOPTERA

ANTENNAE AND PARTS OF LABIUM

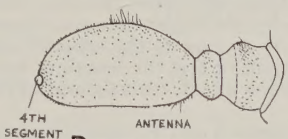
PLATE 3.



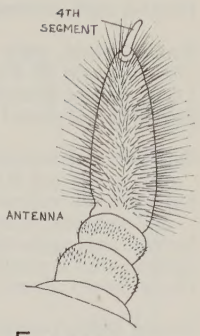
A. AESCHNA

B. TACHOPTERYX

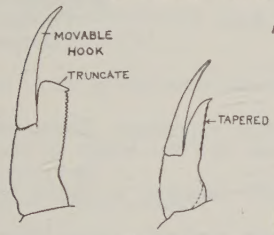
C. DROMOGOMPHUS



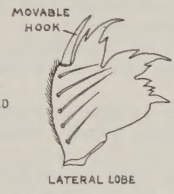
D. OCTOGOMPHUS



E. PROGOMPHUS

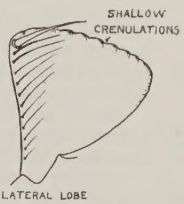


F. BOYERIA G. BASIAESCHNA

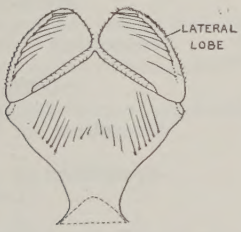


H. CORDULEGASTER

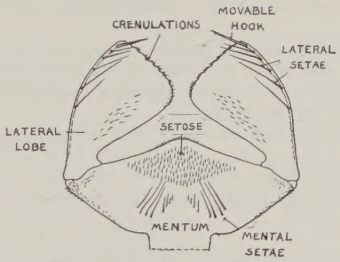
I. PANTALA



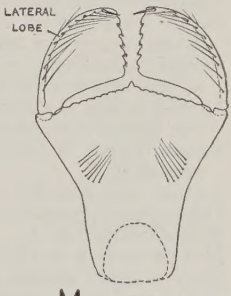
J. TRAMEA



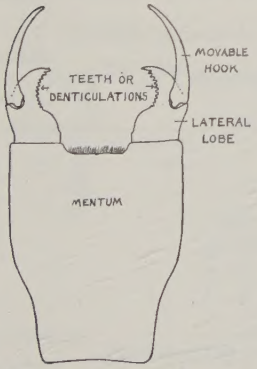
K. LIBELLULA



L. EPICORDULIA



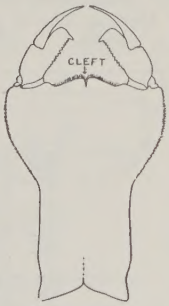
M. PLATHEMIS



N. DROMOGOMPHUS

O. CORYPHAESCHNA

Q. PACHYDIPLAX



P. AESCHNA

5. Frontal shelf, between bases of the antennae, produced into a prominent flat triangle (2 E), **Platycordulia**
   Frontal shelf, between bases of the antennae, low and rounded, not produced into a flat triangle (2 F) ..... **Neurocordulia**
6. Distal half of dorsal surface of mentum heavily setose; lateral setae 4 to 5 (3 L), **Epicordulia**
   Distal half of dorsal surface of mentum with few or generally no setae; lateral setae 6 to 8, **Tetragoneuria**
7. Superior and inferior anal appendages long; as long as mid-dorsal length of abdominal segments 8 and 9 (5 E) ..... **Cannacria**
   Superior and inferior anal appendages short; shorter than mid-dorsal length of abdominal segments 8 and 9, usually not longer than mid-dorsal length of either segment (5 H), 8
8. Lateral anal appendages nearly as long as the superior appendge 9
   Lateral anal appendages one-half or less the length of superior appendage 10
9. Dorsal hooks absent on segments 3 to 4, crenulations of the lateral lobes deep (3 I), **Helocordulia**
   Dorsal hooks present on segments 3 and 4; crenulations of lateral lobes shallow (3 J), **Somatochlora**
10. Mental setae 9–10; length when full grown less than 18 mm.; dorsal hooks on segments 3–9 11
    Mental setae 14–15; length 24 mm. when full grown; dorsal hooks on segments 2–9, **Brechmorhoga**
11. Lateral setae 5; crenulations of distal margin of lateral lobe deep ..... **Perithemis**
    Lateral setae 7–10; crenulations of lateral lobe obsolete ..... **Dythemis**
12. Eyes at side lateral of head, (2 G, H, I and J, *see Note 3*) 13
    Eyes capping the cephalo-lateral angles of the head, more frontal than lateral, (2 A, B and C, *see Note 3*) 17
13. Lateral setae 7; lateral anal appendages nearly as long as superior appendage. . **Dorocordulia**
    Lateral setae 7 to 14; lateral anal appendages usually about half the length of the superior appendage 14
14. Dorsal hook present on segment 3; inferior anal appendages subequal in length to superior appendage 15
    Dorsal hook absent on segment 3; inferior anal appendages markedly longer than superior appendage 16
15. Dorsal hook present on segment 2; lateral spines of segment 9 as long or longer than lateral margin of segment ..... **Macrodiplax**
    Dorsal hook absent on segment 2; lateral spines of segment 9 one-half or less the length of segment 9; or if as long the apex not curved medially ..... **Leucorrhinia** (in part)
16. Lateral spines of abdomen long and straight, those of segment 9 extending to or beyond the tips of the inferior anal appendages ..... **Celithemis**
    Lateral spines of abdomen short, not reaching tips of anal appendages, curved toward meson (5 F) ..... **Sympetrum** (in part)
17. Inferior and superior anal appendages subequal in length 18
    Inferior anal appendages noticeably longer than the superior ..... **Sympetrum** (in part)
18. Mental setae 0 to 4 ..... **Ladona**
    Mental setae 8 to 15 (3 K) 19
19. Body smooth; mental setae 14 to 15; low dorsal hooks on segments 2 to 6; crenulations of lateral lobes very deep (3 I) ..... **Paltothemis**
    Body hairy; mental setae 8 to 13; dorsal hooks on segments 3 to 6 or 8; crenulations moderate or absent (3 J) 20
20. Median lobe of labium crenulate on its distal margin (3 M); abdominal segments 7 to 9 with black, shining mid-dorsal ridges ..... **Plathemis**
    Median lobe of labium evenly contoured (3 K); abdominal segments 7 to 9 without such ridges ..... **Libellula**

Explanation of Plate 4

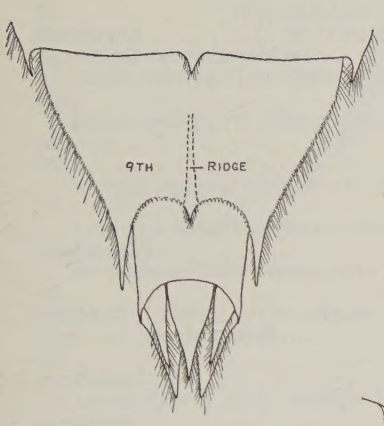
ANISOPTERA

A. Dorsal view of caudal segments of *Dromogomphus*.
B. Lateral view of caudal segments of *Dromogomphus*.
C. Dorsal view of caudal segments of *Gomphus*.
D. Lateral view of caudal segments of *Gomphus*.
E. Dorsal view of caudal segments of *Gomphoides*.
F. Ventral view of caudal segments of *Basiaeschna*.
G. Dorsal view of caudal segments of *Basiaeschna*, parts named.
H. Dorsal view of caudal segments of *Nasiaeschna*.
I. Ventral view of thorax of *Progomphus*.
J. Ventral view of thorax of *Gomphus*.
K. Dorsal view of caudal segments of *Tachopteryx*.

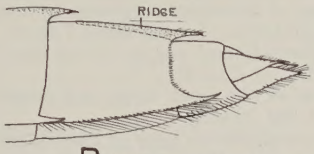
ODONATA – ANISOPTERA

PLATE 4.

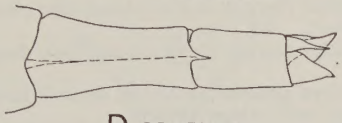
CAUDAL SEGMENTS &c



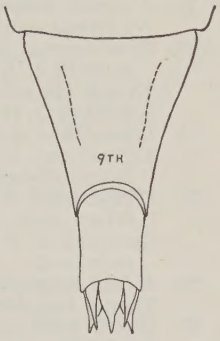
A. DROMOGOMPHUS
DORSAL VIEW



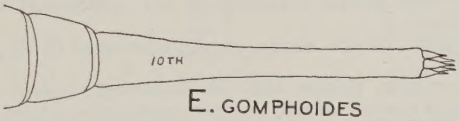
B. DROMOGOMPHUS
LATERAL VIEW



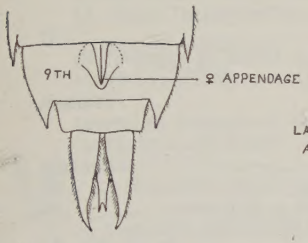
D. GOMPHUS
LATERAL VIEW



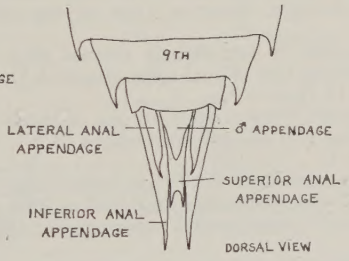
C. GOMPHUS
DORSAL VIEW



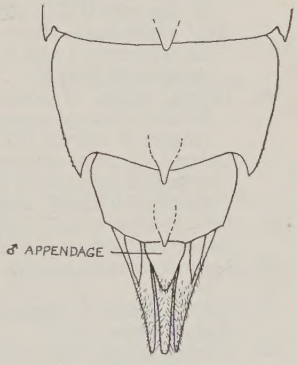
E. GOMPHOIDES
DORSAL VIEW



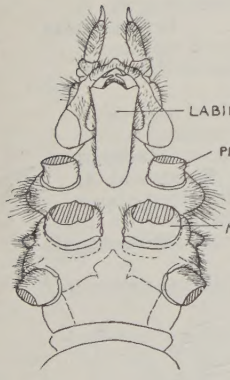
F. BASIAESCHNA
VENTRAL VIEW



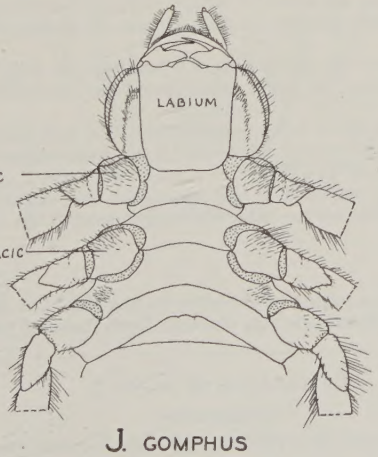
G. BASIAESCHNA



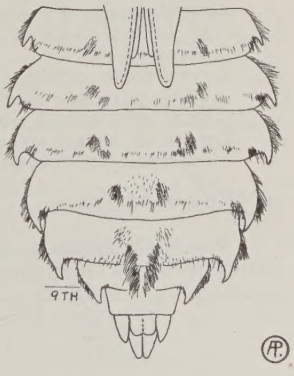
H. NASIAESCHNA
DORSAL VIEW



I. PROGOMPHUS
VENTRAL VIEW



J. GOMPHUS
VENTRAL VIEW



K. TACHOPTERYX
DORSAL VIEW

21. Apical third of inferior and lateral anal appendages strongly decurved (5 G)....22
Apical third of all anal appendages straight, not decurved ventrally (5 I)....23
22. A minute lateral spine on abdominal segment 9; lateral setae 11 or 12....**Lepthemis**
No lateral spines on abdomen; lateral setae 7 to 9....(=**Mesothemis**) **Erythemis**
23. Eyes capping the cephalo-lateral angles of the head, usually small and not very prominent (2 A, B and D, *see Note 3*)....24
Eyes at the side lateral of the head, large and prominent on a usually triangular shaped head (2 G, H and I, *see Note 3*)....29
24. Lateral anal appendages nearly as long as the superior....25
Lateral anal appendages one-third to one-half as long as the superior; crenulations of lateral lobes shallow or absent (3 J)....27
25. Crenulations of the distal margin of the lateral lobe obsolete, merely indicated by about fifteen single spinules....**Pseudoleon**
Crenulations of the distal margin of the lateral lobe deep with groups of 2–7 spinules on each tooth....26
26. A dark longitudinal stripe present along the dorso-lateral margins of the thorax...**Cordulia**
Thorax unicolored, no such stripe present....**Somatochlora** (in part)
27. Lateral spines present on abdominal segments 8 and 9....28
Lateral spines present only on abdominal segment 9....**Tarnetrum**
28. Mentum with distal margin crenulate (3 M); abdominal segments 4 to 7 with dorsal tufts of long hair....**Orthemis**
Mentum with distal margin entire, evenly contoured (3 K); abdominal segments 4 to 7 not as above....**Libellula**
29. Anal appendages long, slender and needle-pointed; lateral spines of segments 8 and 9 long and curved toward meson, those on segment 8 at least as long as mid-dorsal length of segment 9 (5 J, K)....30
Anal appendages short and heavy, not projected into a long, needle-point; lateral spines on segments 8 and 9 flat and straight, those on 8 not as long as mid-dorsal length of segment 9 (5 I)....31
30. Lateral spines of abdominal segment 8 but slightly shorter than those of segment 9; lateral spines of segment 9 reaching tips of anal appendages (5 J): crenulations of distal margin of lateral lobe shallow (3 J)....**Tramea**
Lateral spines of abdominal segment 8 only one-third size of those of segment 9; lateral spines of segment 9 not reaching tips of anal appendages (5 K); crenulations of distal margin of lateral lobe deep (3 I)....**Pantala**
31. Lateral setae 6 to 7; lateral anal appendages more than half as long as the inferiors....32
Lateral setae 9 to 14; lateral anal appendages less than half as long as inferiors....33
32. Lateral setae 6; mental setae 9 to 11; inferior and superior anal appendages subequal in length....**Nannothemis**
Lateral setae 7; mental setae about 14; inferior anal appendages longer than superior appendage....**Cordulia**
33. Lateral spines absent on segment 8....**Tarnetrum**
Lateral spines present on segment 8....34
34. Lateral spines of abdominal segments 8 and 9 subequal in length; some species with prominent bunches of setae present on the dorsum of abdominal segments 4 to 9, **Erythrodiplax**
Lateral spines of abdominal segments 8 and 9 unequal in length; those of segment 8 about half those of segment 9; never with prominent bunches of setae as described above (5 I)....35
35. Lateral spines of segment 9 equal to or greater than the mid-dorsal length of segment 9 (5 I); antennae colored black and white (3 Q); a dark colored ridge running mesad from meso-caudal portion of eye (2 H)....**Pachydiplax**
Length of lateral spines of segment 9 less than the mid-dorsal length of segment 9; antennae not colored as above; no ridge running mesad from eyes as described above (2 I)....**Leucorrhinia** (in part)
36. Nymphs unknown....**Williamsonia**

Note 3. In certain cases the position of the eyes on the head is a difficult point to determine; in such instances the specimens should be run through both forks of the key.

Explanation of Plate 5

ANISOPTERA

Caudal segments of abdomen, all dorsal views except G.

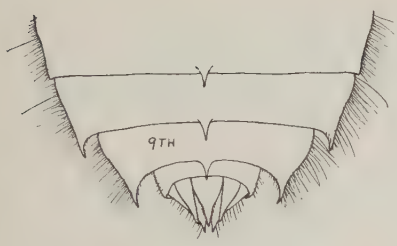
A. *Macromia*.
B. *Didymops*.
C. *Neurocordulia obsoleta* Say.
D. *Neuroorcdulia yamaskanensis* Prov.
E. *Cannacria*.
F. *Sympetrum*.
G. *Mesothemis*, lateral view.
H. *Perithemis*.
I. *Pachydiplax*.
J. *Tramea*, parts named.
K. *Pantala*.

ODONATA – ANISOPTERA

PLATE 5.

CAUDAL SEGMENTS

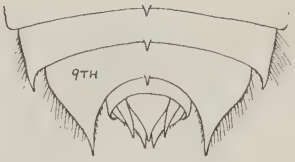
DORSAL VIEWS



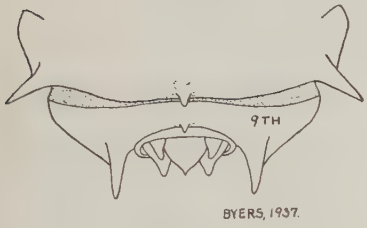
A. MACROMIA

BYERS, 1936

E. CANNACRIA

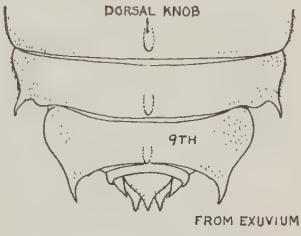


B. DIDYMOPS



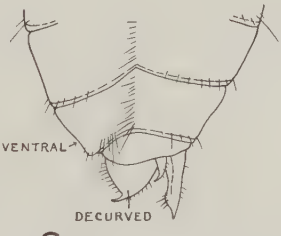
BYERS, 1937.

C. NEUROCORDULIA
OBSOLETA

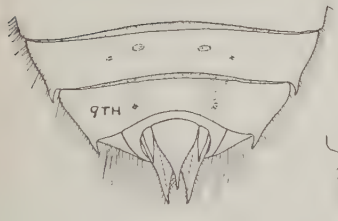


FROM EXUVIUM

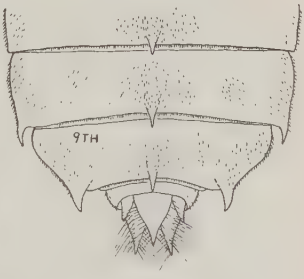
D. NEUROCORDULIA
YAMASKANENSIS



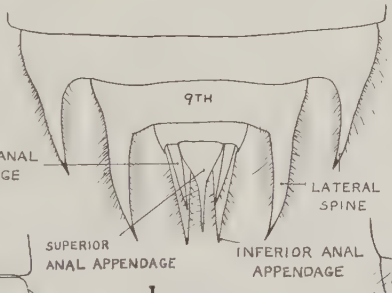
G. MESOTHEMIS
LATERAL VIEW



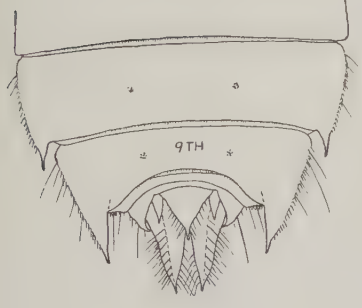
F. SYMPETRUM



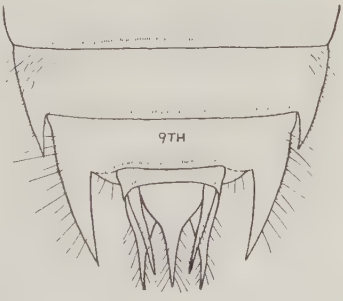
H. PERITHEMIS



J. TRAMEA



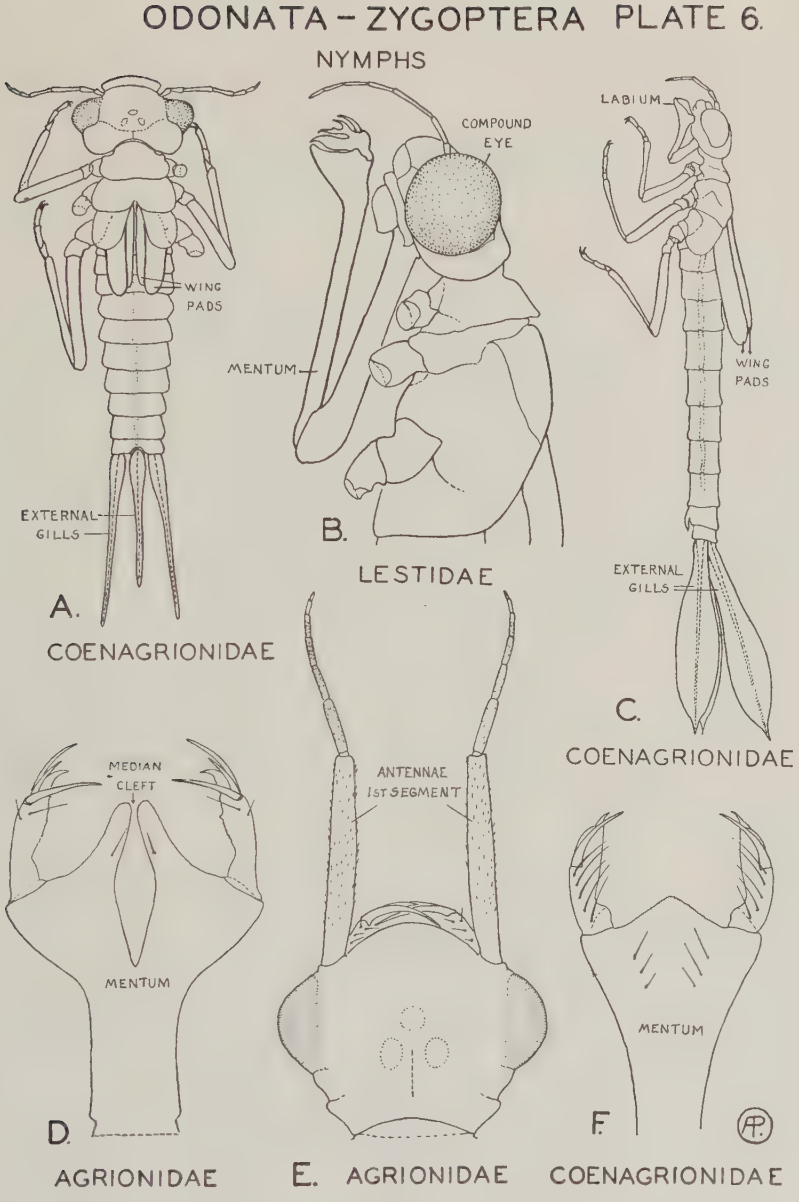
I. PACHYDIPLAX



K. PANTALA

Glossary

Acute—A ridge or projection sharply pointed at apex (4 A and B).
Anal appendages—the five movable appendages (4 G and 5 J) borne on the distal end of the abdomen, namely: superior (1); inferior (2); lateral (2). See further discussion under each.
Angulate—produced into an angle, used in describing the contours of head and body surfaces. (2 K).
Apex (apical)—the distal portion or end of an appendage.
Base (basal)—the proximal portion or base of an appendage.
Cleft—On the labium a longitudinal split present on the meson of the mentum, referred to as mental or median cleft 3 O and P.
Conic- —A short, knob-like structure, used here in describing the fourth antennal segment of certain Gomphines (3 C and D).
Contour—The outline or periphery of surfaces.
Crenulate—having small blunt teeth (scallops) which are evenly rounded and rather deeply curved (3 I and J).
Crenulations—the name applied to the individual small rounded teeth described above.
Cylindrical—elongate and round, used in describing appendages (3 C, third segment).
Decurved—bent or curved downward (ventrally). Used to describe anal appendages of certain genera (5 G).
Denticulate—having small usually sharp pointed teeth (3 N).
Denticulation—term applied to an individual tooth described above.
Depressed—flattened dorso-ventrally.
Divergent—not parallel, projecting away from the median line. Used to describe certain wing pads and lateral spines. (Plate 1, compare wing pads of fig. C with those of fig. E and plate 5 C, see lateral spines of segment 8).
Dorsal hook—a stout usually prominent spine located on the mid-dorsal line of the abdominal segments (1 E and F). In some cases these may be knob-like (5 D).
Elongate—lengthened, much longer than wide. Compare 10th abdominal segments of 4 E and 4 G.
Emarginate—with an obtuse, rounded or quadrate section cut from a margin. See superior appendages of 4 F and G.
Entire—with an even, unbroken margin and not denticulate or crenulate, note distal margin of mentum (3 L).
External gills—present in the Zygoptera. These are the tracheal gills in the form of three flat or triangular, elongate plates borne on the caudal end of the abdomen. They consist of one median and two lateral gills (6 A and C).
Frontal horn—a pyramidal projection of the forehead located between the bases of the antennae (2 M and N).
Inferior anal appendages—a pair of identical structures borne on the ventro-caudal margin of the tenth abdominal segment, morphologically they are the paraprocts (subanal or podical plates) (4 G and 5 J).
Lateral anal appendages—a pair of identical structures borne on the laterio-caudal margins of the tenth abdominal segment, morphologically these are the cerci (4 G and 5 J).
Lateral lobe—a pair of variably shaped segments articulated to the disto-lateral margins of the mentum of the labium, see various figures 3 F to O.
Lateral setae—long, stout setae borne on the latero-dorsal margins of the lateral lobes (3 H to M).
Lateral spines—spine-like projections from the caudo-lateral margins of certain abdominal segments (4 G and 5 J).
Mentum—The most distal unpaired section of the labium usually bearing distinct lateral lobes. Among higher odonates it is broad, curved and spoon-shaped (3 K to O).
Mental setae—a prominent row of strong setae borne on each proximal half of the dorsal (ental) surface of the mentum. The two rows are usually identical in number and structure (3 K to M).
Mesad—Towards the median plane (or line) of the body.
Meson—the median plane (or line) of the body.
Obsolete—almost or entirely lacking; not fully developed. Used to describe crenulations of the lateral lobes of certain forms. Compare 3 I and 3 J.
Obtuse—not pointed; at an angle greater than a right angle.
Setose—thickly covered with setae (3 B, E and L).
Sub—The prefix *sub* is used to denote that the structure described is almost as noted; i. e., subcircular, suboval, subequal, subtruncate, etc.
Superior appendage—an unpaired structure borne on the mid-dorso-caudal margin of the tenth abdominal segment, morphologically the epiproct (supra-anal plate), (4 G and 5 J).
Taper-pointed—with a sharp point which may curve somewhat (3 G).
Terminal abdominal segments—segments 8, 9, and 10.
Teeth—see crenulations.
Truncate—cut off squarely at tip (3 F).
Tubercle—a rounded knob-like projection of the head or body surface (2 L).



Explanation of Plate 6

ZYGOPTERA

A. *Coenagrionidae*, dorsal view.
B. *Lestidae*, lateral view of cephalic end.
C. *Coenagrionidae*, lateral view.
D. *Agrionidae*, mentum and lateral lobes.
E. *Agrionidae*, dorsal view of head.
F. *Coenagrionidae*, mentum and lateral lobes.

References to the Literature Available for Identification of Species of the Anisopterous Dragonflies of the United States and Canada

Petaluridae

Tachopteryx.....Selys-Williamson (1901); Needham (1929).

Gomphidae

Progomphus Selys.....Byers (1939). Excellent study of the genus.

Hagenius Selys.....A single species, *H. brevistylus* Selys.

Ophiogomphus Selys.....Kennedy (1917) and Walker (1933). Excellent.

Octohomphus Selys.....A single species, *O. specularis* Hagen.

Gomphoides Selys.....There are but two species at present listed under this genus: *G. williamsoni* Gloyd with the elongate tenth abdominal segment; and *G. stigmata* Say with the tenth segment normal and known only from Texas.

Erpetogomphus Selys.....There are four species in our area of which *E. designatus* been described from raised material by Hagen (1885) and *E. compositus* by supposition, see Hagen (1885).

Dromagomphus Selys.....Three known species. Only one, *D. spinosus* Selys has been described. See Garman (1927) or Byers (1930).

Lanthus Needham.....Two known species. One, *L. parvulus* Selys, described from supposition by Needham (1901).

Gomphus Leach.....This is the largest genus in our fauna, and many of the nymphs are as yet unknown. Several regional publications are of considerable value, but the collector must at all times remember that many of the species are unknown in the nymphal stage. Nymphs of this genus should be checked by some authority. The following papers may be consulted: Needham and Heywood (1929) general; Kennedy (1917) western forms; Byers (1930) southeast; Garman (1927) New England; and Walker (1928) for the subgenus *Stylurus*.

Aeshnidae

Gomphasechna Selys.....Two species in our fauna. The generic characters of the genus are briefly indicated by Martin (1940).

Basiaeschna Selys.....A single species—*B. janata* Say.

Boyeria McLachlan.....Two species. Garman (1927), and Walker (1913 and 1915).

Anax Leach.....Byers (1927) and Calvert (1934).

Oplonaeschna Selys.....A single species, *O. armata* Hagen. Nymph unknown.

Coryphaeschna Williamson..Two species in our fauna. Kennedy (1919) described the nymph of *C. ingens* Rambur. *C. virens* Rambur is unknown in the nymphal stage.

Nasiaeschna Selys.....A single species, *N. penthacantha* Rambur.

Epiaeschna Hagen.....A single species, *E. heros* Fabricius.

Aeshna Illiger.....Composed of 18 species of which nymphs have been described for 15. See Walker (1912, 1914, 1921, 1934, and 1941) and Kennedy (1917).

Gynacantha Rambur.....Probably but a single species in our fauna, *G. nevrosa*, Rambur, which is illustrated by Williams (1937). *G. bifida* Rambur has been recorded from Florida but according to Byers (1930) an examination of material and reports leads to the belief that all such records were based on misidentification of *G. nervosa*.

Triacanthagyna Selys.....A single species in our fauna, *T. trifida* (Rambur). Nymph unknown, but probably generaically similar to *Gyncantha*.

Cordulegasteridae

Cordulegaster Leach.....Eight species have been recorded from our fauna. Needham and Heywood (1929) give a key to the nymphs of six of these. Kennedy (1917) gives excellent descriptions and illustrations of the two far western species. Byers (1930) describes the southern form.

Libellulidae

Macromiinae

Macromia Rambur.....Nine species, known from our fauna. The nymphs of four are known. Needham and Heywood (1929); Kennedy (1917) excellent illustrations; and Walker (1937) excellent illustrations.

Didymops Selys.....Two species. *D. transversa* Say well described by Byers (1930) and Garman (1927. *D. floridensis* Davis nymph unknown.

Cordulinae

Platycordulia Williamson...A single species, *P. xanthasoma* Williamson.

Neurocordulia Selys.....See Byers (1937).

Epicordulia Selys.....Two species. Needham and Heywood (1929).

Tetragoneuria Hagen.....The number of species in this genus is open to question. Very little dependence can be placed on nymphal determinations other than generic. Needham and Heywood (1929); Garman (1927); Byers (1930).

Helocordulia Needham .....Two species. Needham (1901) Needham and Heywood (1929) and Kennedy (1924).

Somatochlora Selys.....A large genus. Walker (1925) wrote an excellent monograph on the genus bringing all information up to that date. Several new species and a few nymphs have been described since.

Cordulia Leach.....A single species, *C. shurtleffi* Scudder.

Dorocordulia Needham.....Two species. See Garman (1927).

Williamsonia Davis.....Two species. The nymphs of both unknown.

Libellulinae

Nannothemis Brauer.....A single species, *N. bella* Uhler.

Perithemis Hagen.....Two species in our fauna: *P. tenera* Say U. S., described by Garman (1927) as *P. domitia*; and *P. seminole* Calvert from Florida, see Byers (1930).

Celithemis Hagen.....Eight species. The nymphs are but poorly known. See Needham and Heywood (1929), Garman (1927), and Byers (1930).

Pseudoleon Kirby.....A single species, *P. superbus* Hagen. See Needham (1937).

Erythrodiplax Brauer.....Needham (1929) and Borror (1942).

Orthemis Hagen.....A single species in our fauna, *O. ferruginea* Fabr.

Ladona Needham.....Needham and Heywood (1929), Garman (1927), and Byers (1930).

Libellula Linnaeus.....A large genus. Byers (1927a) gives very good keys to the known species. Consult also Needham and Heywood (1929) and Garman (1927).

Plathemis Hagen.....Two species. Only the nymph of *P. lydia* Drury is known. See Needham (1901).

Cannacria Kirby.....A single species in our fauna, *C. gravida* Calvert. Well illustrated by Byers (1936).

Sympetrum Newman.....A large rather difficult genus. Consult Walker (1917) and Needham and Heywood (1929).

Leucorrhinia Brittinger.....See Walker (1916, 1940) and Needham and Heywood (1929).

Pachydiplax Brauer.....A single species, *P. longipennis* Burmeister.

Erythemis Hagen (=*Mesothemis*). Two species. Only the nymph of *E. simplicicollis* Say known.

Lepthemis Hagen.....A single neotropical species which barely enters our southern border, *L. vesiculosa* Fabricius.

Dythemis Hagen.....See Needham and Heywood (1929) and Byers (1930).

Brechmorhoga Kirby.....See Needham and Fisher (1936). A single Sonoran species in our southwestern border, *B. mendax* Hagen.

Paltothemis Karsch.....A single species along the southwestern border of our area, *P. lineatipes* Karsch.

Pantala Hagen.....Two species. Needham and Heywood (1929), Garman (1927) and Kennedy (1923).

Macrodiplax Brauer.....A single species in our fauna, *M. balteata* Hagen.

Tramea Hagen.....A very difficult genus for specific nymphal determination. Best discussion by Byers (1927b).

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THE FRESH-WATER NAIADES OF AUGLAIZE COUNTY, OHIO

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This paper deals with 30 collections of mussels taken at 24 stations (Fig. 1) in the drainage systems of Auglaize County during the past four years, 1938–42. The materials are of interest because: (1) no other naiad records have been published for this area; (2) rapid changes in stream ecology necessarily alter the mussel fauna; and (3) the proximity of headwater streams of the Ohio and Lake Erie drainages produce interesting distribution patterns for comparison. In the general vicinity, Goodrich (1914) reported on naiades from the Wabash River in Mercer County; Clark and Wilson (1912) surveyed the Maumee and Auglaize Rivers of Defiance County; Kirsch (1894) investigated the Maumee Basin; Ortmann (1919) reported on mussels from the St. Marys River, Beaver Creek, and Lake St. Marys in Mercer County, the Maumee River in Defiance County, the Scioto River in Hardin County, and Indian Lake in Logan County. These collections have been made in counties to the west, north and east of the region considered at present. Records of Sterki (1907) and those from the Carnegie Museum of Pittsburgh list specimens from the Great Miami drainage to the south. This paper presents data on the origin of the naiades of Auglaize County, the species involved, their distribution and ecology, together with a brief discussion on the future of naiades in the county.

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PHYSIOGRAPHY OF AUGLAIZE COUNTY

Auglaize County occupies an area of 398 square miles on the top of the watershed between the Ohio and Lake Erie drainages in west central Ohio. During glacial times, the region was buried under the ice. Numerous halts characterized the retreat of the glacier and during these periods large beds of drift were deposited at the ice margin (Hobbs 1921: 311). Such deposits lend a sag and swell aspect to the county characterized by its broad moraines and interlying, rather level, plains. Because of the position of these moraines, the present drainage is in three directions: southward through tributaries of the Great Miami and Scioto Rivers in the eastern and southern parts of the county, northward through the Auglaize River in the center, and westward through the St. Marys River in the western part.

According to Winchell (1894: 406), "The soil of the county is essentially clay. Various local circumstances have caused accidental qualities to modify it." He also indicates that the St. Johns and Wabash moraines are characterized by a gravelly clay soil while that of the St. Marys is "simply a broad undulation, or thickening of the drift," and is composed of coarse heavy clay. Leverett (1902: 522 and 561) indicates that the plains between the ridges have a deep black soil which Dachnowski (1912: 104) describes as "retentive clay" with deep humus covering the clay.

Originally, the county was chiefly forested with the exception of a few wet prairies in the extreme eastern and western parts. The northwestern townships were on the border of the Black Swamp area and thus characterized by wet lowland forests. Today, the major portion of the county is under cultivation.

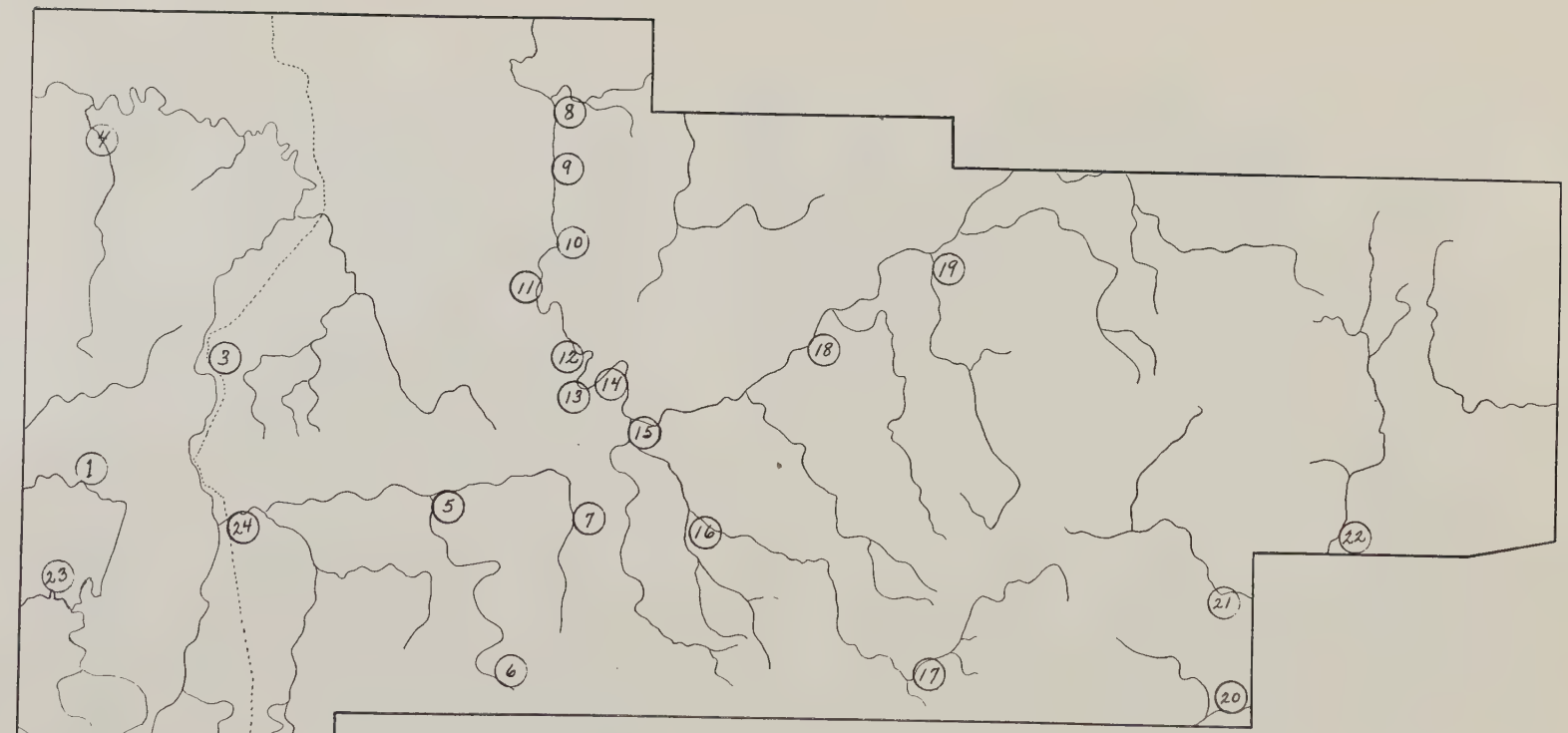

FIG. 1. Stations of collections made in Auglaize County.

SOURCES OF AUGLAIZE COUNTY NAIAD FAUNA

Walker (1913: 58) states: " . . . the original pre-glacial fauna of the present St. Lawrence system was absolutely exterminated during the glacial period, and . . . the peculiar fauna now characteristic of Lake Erie is the result of a modification from environmental causes of the postglacial immigrants from the south, and not the result of any survival in that region of any part of the pre-glacial fauna."

Ortmann (1924: 101–117) reviews the theories on the stocking of Lake Erie with naiades and advances his own explanation. His theory postulates a Maumee River which flowed westward through the dry bed of what is now Lake Erie, and connected with the Wabash River. Later, with the closing of the Trent and Nipissing outlet stages, the waters flowed into the Lake Erie basin, "drowning the lower parts of the Maumee River and its tributaries, which then became tributaries to Lake Erie." Carrying these postulates farther, van der Schalie (1933: 11) states that the fauna in the flooded basin either died out or became modified to produce those forms which are recognized as lake forms of the earlier river types. Thus, we may say that the St. Marys and Auglaize Rivers received their original faunas as migrants up the Greater Maumee of Ortmann and into these tributary streams.

"The Wabash and Erie Canal," according to Clark and Wilson (1912: 7), "became a channel of communication which during its half century of existence must have resulted in the exchange of many species of mussels." The Miami and Erie Canal must have acted in a similar way for mussel migration from the Auglaize River through the canal into Lake St. Marys and into the Wabash River. Goodrich (1914: 132) states: "There is excellent reason for believing that the Unione fauna of the Maumee has received additions, by means of this canal [Wabash and Erie], since the days when the upper part of what is now the Maumee water course served as a southward flowing outlet for the glacial Lake Maumee."

Clark and Wilson (1912: 4–5) elaborate on this confluence: "Even at present day the headwaters of the Little Wabash River approach within three miles of the St. Marys and still nearer to small affluents of that stream. . . . There is no perceptible divide between the two basins, and a large open country ditch still unites them through an old flat lake plain known locally as the 'prairie.' A careful examination of this ditch revealed no mussels at all, and it is not likely they could live in the mucky bottom, though it is possible that glochidia might be carried through the stream by migrating fishes." Finally Ortman (1924: 114–115) states, "There is, indeed, the possibility, that in other rivers in the state of Ohio some faunal elements of the upper Ohio drainage may have reached the lake-tributaries by stream-piracy in the region of the headwaters."

According to Goodrich (1914: 131–132) flood waters from the St. Marys River spread across "the prairies" mentioned above by Clark and Wilson, connecting the Wabash and St. Marys River systems during the great flood of March-April, 1913. He also states: "The Naiades of the Maumee and the upper parts of the Wabash now very nearly approximate one another, counting the recent additions for which the Wabash and Erie canal may be thanked."

The Ohio tributaries in Auglaize County have continuously been open to migrations of naiades from the Ohio and Mississippi Rivers.

DRAINAGE SYSTEMS OF AUGLAIZE COUNTY

1. Auglaize River: The Auglaize River is the largest drainage system in the county. Its upper portion in Auglaize County is now dredged and has a fine sand bottom, with only a few inches of water. The remainder is a series of pools and riffles with gravel and rubble bottom, and bordered with water willow (*Dianthera americana*) and lizard's tail (*Saururus cernuus*). The stream is characterized by

broad shallow pools of less than 6 feet of water and a gradient of about 4 feet per mile throughout the county.

2. St. Marys River: The St. Marys River above the city of St. Marys is composed of a group of small, clear and shallow tributaries with sand and silt bottoms, and a gradient from 8 to 10 feet per mile. The river below the city is a comparatively shallow sluggish stream, with gravel and deep silt substrata, and less than 3 feet fall per mile.

3. Muchinippi Creek: This creek is a tributary of Wolf Creek belonging to the Great Miami River system. It arises in the prairies of eastern Auglaize County and flows southward. The upper portion, because of dredging, is a straight, mud-bottom ditch. Near the Shelby County line, it takes on the appearance of a creek with relatively clear pools and sand and gravel riffles.

4. Wolf Creek: Only a short stretch of this creek, now dredged and ditch-like, has a sand bottom and a permenent flow of water. It is very shallow and narrow in this county.

5. Lake St. Marys: This is an artificial body of water formed by impounding tributaries of the St. Marys and Wabash Rivers and flooding the prairie divide. It occupies an area of 15,700 acres with less than 10 feet of turbid water over a bottom composed chiefly of blue-gray silt containing some sand and gravel. The south shore is made irregular by the dense mass of emergent vegetation, chiefly cattails (*Typha angustifolia* and *latifolia*). The north shore is more regular with little vegetation and much more affected by heavy wave action.

6. Miami-Erie Canal: The water levels in the canal are maintained by a series of dams and abandoned locks. A series of wide-waters of which 40 Acre Pond is the largest are included in this area. In general, the canal depth is less than 6 feet with the exception of a two mile stretch below New Bremen where dredging has produced 8 feet of water. A deep silt bottom characterizes the canal proper, but sandy-clay shore lines occur along the wide-waters.

7. Lake Loramie: The upper part of the Minster Branch of Lake Loramie is in Auglaize County, but is not discussed because no naiades were taken there.

ANNOTATED LIST OF SPECIES

Quadrula quadrula (Rafinesque)

This species is found in both the Lake Erie and Ohio drainages according to Sterki (1907: 390). It was taken in the Maumee River in Defiance County by Clark and Wilson (1912: 41). Ortmann (1919: 42), speaking of this species, remarks: "In western Ohio it is widely distributed. Here it crosses over into the Lake Erie-drainage (Ohio Canal, Sterki) and into the lake (Sterki and Walker, 1913)." It is locally common and found partly buried in the sand of wave swept areas of Lake St. Marys. It is probably the most abundant naiad inhabiting the lake. One specimen was taken in the canal at station 24.

Amblema costata (Rafinesque)

Sterki (1907: 390) lists this mussel as generally common in both the Ohio and Lake Erie drainages. Clark and Wilson (1912: 42) state that it is the second most abundant species of mussel in the Maumee Basin and quite abundant in the Auglaize River in Defiance County. Ortmann (1919: 30) reports it from the St. Marys River in Mercer County. In Auglaize County, I have found this naiad in only the Auglaize River, where it ranks as one of the most abundant species. Due to dredging in the upper reaches of the river, large beds of this species have been destroyed and its present distribution is chiefly confined to that portion of the stream below Wapakoneta. Specimens were secured at stations 8, 9, 11, 12, 13, 14 and 18, and were especially common at 13, 14 and 18. In general, this species was found in the more quiet pool-like areas with two to four feet of turbid water over a sandy-silt bottom.

Elliptio dilatatus (Rafinesque)

Sterki (1907: 392) records this naiad as found throughout the state. Clark and Wilson (1912: 14) report it fairly common in the Maumee and common in the Auglaize River. I have only a single specimen taken at station 11 in the Auglaize River.

Fusconaia flava (Rafinesque)

Both Sterki (1907: 392) and Clark and Wilson (1912: 39) list this species as a widely distributed naiad. Clark and Wilson state: "It is fairly common all along the Maumee and its tributaries." This species is represented in the St. Marys, Auglaize and Great Miami drainages (stations 10, 13, 14, 18, and 20), although nowhere found in abundance. Ortmann (1919: 30) reports it from the St. Marys River in Mercer County. This naiad is usually found in shallow water over firm sand with either winding trails or only the exposed siphons of the buried mollusk to indicate its presence.

Pleurobema cordatum coccineum (Conrad)

A state-wide distribution of this species is claimed for it by Sterki (1907: 392). However, Clark and Wilson (1912: 39) took only 31 specimens in the Maumee drainage. I found it at only two stations, 18 and 12, in Auglaize County. At the latter station, a dozen specimens were taken from the fine gravel bottom covered by less than 18 inches of water.

Anodonta grandis Say

Sterki (1907: 394) lists this species as state wide in distribution, but Clark and Wilson (1912: 46) found only occasional specimens in the rivers which they investigated. Ten specimens were taken by them from the Auglaize River in Defiance County. Ortmann (1919: 144) reports specimens collected by Goodrich from the St. Marys in Mercer County. I found *A. grandis* to be the most abundant naiad in Auglaize County. It was taken at stations 3, 4, 7, 8, 10, 11, 12, 14, 15, 18, 19, 22, 23 and 24.

This species abounds in sluggish pools with deep soft silt bottoms. The thinner shelled specimens are often found resting on top of the mud while heavier shelled forms may be buried in the riffles.

A great deal of variation in this species is noted by Sterki (1907: 394) and van der Schalie (1938: 51). The latter states, "We do not have sufficient ecological and life-history data to enable us to solve the systematic difficulties which arise from this group. For instance, specimens occurring in lakes tend to be more inflated anteriorly and in the region of the beaks and usually have a finer beak sculpture than those found in rivers. But there are all kinds of intergrades. . . . "

Anodonta imbecillis Say

This interesting species was recorded by Sterki (1907: 395) as, "Over the state, common, in all kinds of waters." Clark and Wilson (1912: 47) found one specimen in the St. Marys River at Ft. Wayne and 38 in the canal at Maumee, Ohio. Ortmann (1919: 164) reports specimens taken by Goodrich in the Miami-Erie Canal in Lucas County, Ohio. This mussel was taken at stations 23, 24, and 19. Its abundance in the dredged channels of Lake St. Marys is indicated by the numerous specimens taken while deepening the channel. The habitats from which my specimens were taken seem to indicate that it prefers soft sand or silt bottom conditions in quiet water areas.

Lasmigona compressa (Lea)

Sterki (1907: 393) attributes to it a state wide distribution, but Clark and Wilson (1912: 46) found only one specimen in their Maumee River work. During this study, one specimen was taken in the Auglaize River at station 11 and five specimens in Wolf Creek at station 20.

Lasmigona costata (Rafinesque)

A state wide distribution for this species is given by Sterki (1907: 393). It was found to be a common species in both the Maumee and Auglaize Rivers by Clark and Wilson (1912: 45–46).

Goodrich also collected it in the Maumee River in Defiance County and in the St. Marys in Mercer County (Ortmann 1919: 128). It was found in Auglaize County at stations 8, 10, 12, 13, 14 and 18 in the Auglaize River proper.

Ortmann (1919: 30) states: "It is found in large rivers as well as in small creeks, although it is distinctly more abundant in the latter. There is hardly any small stream from which it is entirely absent. . . . " As suggested by van der Schalie (1938: 54), I found this statement only partly true. This naiad is distributed throughout the lower Auglaize River in this County, but it does not occur in the upper part or in the larger tributaries. I found the majority of my specimens in shallow, sand and gravel riffles with noticeable current as did Price (1940: 13) in Franklin County, Ohio.

Anodontoides ferussacianus (Lea)

A widespread distribution over the state is claimed for this species by Sterki (1907: 394). However, Clark and Wilson (1912: 46) found no specimens in the Maumee drainage of Ohio. I find this naiad to be widespread over the county in practically all water areas, stations 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 18, 19, 20, 22, and 23. It is especially common at stations 7 and 20, both in small headwater streams. It ranks next to *Anodonta grandis* as the most abundant naiad in Auglaize County. This mussel was most abundant in the more quiet stretches of shallow water living partly buried in the sandy silt.

Two top minnows (*Fundulus notatus*) and one green sunfish (*Lepomis cyanellus*) collected at station 6 in Muddy Creek carried glochidia between the rays of the caudal, dorsal and anal fins. *Anodontoides ferussacianus* was the only species of naiad taken in this creek, and I therefore supposed that the glochidia were of this species.

Strophitus rugosus (Swainson)

This mussel is recorded as widespread over the state, as common and variable by Sterki (1907: 394). But, Clark and Wilson (1912: 47) state that it: " . . . is not common in the Maumee Basin . . . none were seen in the Auglaize River." Goodrich collected it in the St. Marys River in Mercer County (see Ortmann, 1919: 203). It was not found to be common at any location in this county but was taken at stations 7, 11, 12, 13, 17, and 18. This naiad is found most commonly in creeks and small streams with sand, silt, or fine gravel bottoms.

Alasmidonta calceolus (Lea)

A. calceolus is common throughout the state according to Sterki (1907: 393). Clark and Wilson (1912) do not mention this species in their report on "The Mussel Fauna of the Maumee River." During this study, it was found in the Great Miami and Auglaize River systems at stations 15, 16, 17, 19, 21, and 22. It was abundant in Pusheta Creek at station 15, and common at stations 19 in Blackhoof and 22 in Muchinippi Creeks. This species was found only in the smaller creeks where it was usually buried in the sand and gravel on the bars and riffles.

Alasmidonta marginata (Say)

According to Sterki (1907: 393), it is found over the state in both the Ohio and Lake Erie drainages. Ortmann (1919: 185) lists it from the Maumee River in Defiance County, but it was not mentioned by Clark and Wilson (1912). During four years of collecting in Auglaize County, I have taken one specimen. This was collected at station 13 in the Auglaize River. The ecology of this species is given by van der Schalie (1938: 61) as follows: "In the small-river areas of the upper part of this drainage [Huron River] it occurs on a sand and gravel bottom in current."

Ptychobranchus fasciolare (Rafinesque)

This species occurs in both drainages in Ohio according to Sterki (1907: 390), but was not abundant anywhere in the Maumee Basin according to Clark and Wilson (1912: 48). Goodrich also collected it in the Maumee River in Defiance County (Ortmann, 1919: 211). I have only two specimens from Auglaize County, both from the Auglaize River and taken approximately one mile apart. Henry van der Schalie (1938: 61) states it, " . . . is usually found buried deep in an unshifting sand and gravel bottom in rapids and seems to show definite aversion toward ponded or backwater conditions."

Micromya iris (Lea)

Sterki (1907: 389) lists this species as occurring in both drainages and Clark and Wilson (1912: 51) claim it does not appear to be common in the Maumee Basin but is probably more common than collections would indicate. Only five specimens were taken in the county, one at station 12 and four at station 18, all in the Auglaize River proper. In every instance specimens were taken in sand deposits on the downstream side of large patches of water willow in shallow water.

Carunculina parva (Barnes)

According to Sterki (1907: 389) this mollusk is found, " . . . over the state (both drainages, Lake Erie); rivers, creeks, and canals." My records show this species as common at station 4 in Hussey's Creek, but rare at stations 3, 7, 15 and 18. This mussel has been collected frequently in Lake St. Marys in Mercer County, but as yet I have found none in the Auglaize County end of the lake. All collections were taken from fine sand silt and clay in shallow waters.

Lampsilis fasciola Rafinesque

Sterki (1907: 388) gave as its distribution, "both drainages, over the state." Clark and Wilson (1912: 54) state: "This very attractive little mussel was not common in the Maumee Basin. . . . " Goodrich collected it in the Maumee River in Defiance County (Ortmann, 1919: 311). My one specimen from this county was found at station 13 in the Auglaize River. Ortmann (1919: 311) describes its habitat as follows: "In Pennsylvania it distinctly prefers riffles with lively currents and gravelly bottoms, but it is not found in very strong currents and among large rocks."

Lampsilis siliquoidea (Barnes)

The distribution as given by Sterki (1907: 388) is "Over the state, common and variable; common in Lake Erie and decidedly variable. . . . " Clark and Wilson (1912: 52–53) indicate its widespread distribution in the Maumee Basin, and Goodrich (Ortmann, 1919: 286) collected it in the St. Marys River in Mercer County. It was taken at stations 7, 8, 10, 12, 13, 14, 15, 18, 20, and 21 in the Great Miami, Auglaize and St. Marys river drainages. It is locally very abundant and would probably rate as third in abundance in the county.

Like Ortmann (1919: 288), I found it prefers rather quiet water and sandy-mud bottom conditions. Much variation in specimens is noted. Ortmann (1919: 291), concerning the subspecies *rosacea*, remarks: "I have the impression that *rosacea* is not so much a geographical, as an ecological race, produced by the environment of great lakes, and that it turns up wherever the proper conditions are offered." Variation in this species is shown in relation to exposure by Brown, Clark and Gleissner (1938, Fig. 3). The same authors state (1938: 699), "The differences found between individuals of the same species from streams and lakes does not seem so singular when series from a large number of habitats within lakes and streams are compared. Such a series certainly shows complete intergradation for the shell characters of size and shape. A suitable stream habitat favors the large sizes and the exposed large lake habitat, the extreme cases of stunting."

Lampsilis ovata ventricosa (Barnes)

Sterki (1907: 388) states that *L. ventricosa* occurs over the state, is very variable, and is also common in Lake Erie. He states further that *L. ovata* occurs in the Ohio and Greater Miami Rivers. Clark and Wilson (1912: 54) state that *L. ventricosa*, in some localities, runs into a species which in its form is known as *L. ovatus* but, "in the Maumee Basin it is well marked and fairly uniform." Ortmann (1919: 304–305) lists northwestern Ohio specimens as *L. ovata ventricosa* and gives the following specific records: the Maumee River in Lucas and Defiance Counties; Beaver Creek in Williams County; and the Scioto River in Hardin County. He (1919: 303) states that both *L. ventricosa* and *L. ovata ventricosa* are, "forms of the same species connected by numerous intergrades, but locally may be pure." The Specimens of Auglaize County can well be placed as intergrades from a transition zone. The difficulties in the systematics of these forms are discussed by Ortmann (1919: 298) and they will not be discussed here. Only five specimens were collected in the county at stations 12, 13, 15 and 18. These were taken in pool-like

areas on the downstream side of beds of water willow in deposits of soft sand and silt. These data agree with Ortmann's observations (1919: 306).

Uniomerus tetralasmus Ortmann

The variety *U. tetralasmus camptodon* (Say) is recorded from the Great Miami River by Sterki (1907: 392) and was taken in Lake St. Marys in Mercer County. It is locally very abundant in the Miami-Erie Canal. Many shells are cast upon the beaches of Lake St. Marys by the wave action but no living specimens have been taken from the lake during my collecting. From the shells on the beaches, we may assume it to be fairly common in the lake.

	St. Marys River	Hussey's Creek	Barrington's Creek	Clear Creek	Carter Creek	Muddy Creek	Auglaize River	Two Mile Creek	Pusheta Creek	Owl Creek	Quaker Run	Dry Run	Blackhoof Creek	Virginia Creek	Wrestle Creek	Muchinippi Creek	Willow Creek	Wolf Creek	Miami-Erie Canal	Lake St. Marys	Behm's Creek	Lake Loramie
Quadrula quadrula							x													x		
Amblema costata							x															
Elliptio dilatatus							x															
Fusconaia flava							x											x				
Pleurobema cordatum coccineum							x															
Anodonta grandis		x		x			x	x	x				x			x		x	x			
Anodonta imbecillus							x						x			x		x				
Lasmigona compressa							x											x				
Lasmigona costata							x															
Anodontoides ferussacianus		x		x		x	x	x	x				x			x		x				
Strophitus rugosus				x			x		x													
Alasmidonta calceolus									x				x			x	x					
Alasmidonta marginata							x															
Ptychobranchus fasciolare							x															
Micromya iris							x															
Carunculina parva		x		x			x		x										x			
Lampsilis fasciolare							x															
Lampsilis siliquoidea				x			x		x								x	x				
Lampsilis ovata ventricosa							x		x													
Uniomerus tetralasmus																			x	x		

FIG. 2. Distribution of species in the water areas of Auglaize County.

FUTURE OF AUGLAIZE COUNTY NAIADES

Numerous factors combine to limit the abundance of mussels in any body of water. The influences of civilization are proving detrimental to the fauna of this county. The most serious limiting factor is that of erosion silt. Ellis (1931: 5) states, "The outstanding factor producing changes in river conditions at present throughout the Mississippi River system was found to be erosion silt." Dredging in the headwaters of the Auglaize River in 1940 (Clark 1942: 10), " . . . resulted in placing such quantities of silt in suspension as to form the chief sources of pollution in the river. This silt was deposited approximately 4 miles downstream, covering the gravel and rubble bottom to a maximum depth of 4 inches." The filling in of backwater areas and the increasing turbidity of Lake St. Marys are of concern to all who are interested in this lake. Ellis (1931: 6–7) indicates that the heavy silt loads of streams create unstable bottom conditions, cover mussel beds and juvenile mussels and, " . . . affects the mussel survival of both young and adults through the oxygen supply." The suitability of the soil of Auglaize County

for tillage, the removal of existing timber, and increasing demands on agriculture will without doubt result in more dredging, ditching and tiling, thus increasing the silt load of our streams.

The small size of most of Auglaize County streams implies an irregularity of flow which possibly ranks with erosion silt as one of the most limiting factors of a large naiad population. The Auglaize and St. Marys Rivers, Blackhoof, Pusheta, Muddy, Clear, Muchinippi and Wolf Creeks are permanent streams, (note naiad distribution in Fig. 2) but the remaining ones become intermittent during the dry seasons. All streams of this county were once spring fed and the increasing irregularity in stream flow indicates the disappearance of these springs. As early as 1907, Sterki (1907: 368) mentioned this factor as one of those responsible for the disappearance of mollusca.

The problem of pollution is one of importance in the St. Marys River below the city of St. Marys and in the Auglaize River below Wapakoneta. Deposits of sludge are common in both causing the elimination of the naiades.

The changes in the ecological factors of the streams through irregularity of stream flow, pollution, and increasing silt loads have resulted in increased turbidity, decreased amounts of vegetation, changes in the substratum and a corresponding change in fish life or hosts for the parasitic stages of naiades. A comparison of reports by Clark (1942: 1–171) and Kirsch (1894: 334–337) show that Kirsch obtained 14 species of fish not found at present in the upper portion of the St. Marys River. This means a loss of 14 potential hosts of the parasitic naiad stages.

The impounding of streams and the subsequent silting over of mussel beds (Ellis 1931: 8) has not become a serious problem in this county. One dam in the Auglaize River at Wapakoneta impounds possibly a mile of the stream. This dam may impede the upstream migration of fish and thereby reduce the number of hosts for the parasitic mussel glochidia.

Sterki (1907: 368) states, "The canals, which were great routes for mollusca, are more and more neglected, and partly abandoned." The Miami-Erie Canal with its chain of small ponds is intact throughout Auglaize County, but abandoned in Shelby County to the south and Allen County to the north. Portions of the canal are held at their original levels by a series of dams and locks, but the deep soft mud banks and the limited number of species of fish do not provide attractive conditions for a heterogeneous mollusca population.

The collecting of mussels for pearls or for the button industry has not affected the population of this county. I have never seen or heard of a pearl or button shell collector in this county and doubt if one will work these streams because the naiad population is too small to induce such activities.

We have a fair muskrat population in this county but as yet I have not found one of the "kitchen middens." In the adjacent county, Logan, I have counted as many as 195 pairs of shells of *Anodonta grandis*, *Quadrula quadrula*, and *Carunculina parva* at one of these feeding sites at Indian Lake. H. van der Schalie (1938: 75), states that, " . . . the muskrat and mink are most destructive to them [naiades] in the river and lakes above Ann Arbor.

SUMMARY AND CONCLUSIONS

1. The naiad fauna of Auglaize has been found to consist of 19 species.
2. A new host is reported for the glochidia of *Anodontoides ferussacianus*.
3. The naiad fauna of Auglaize County is a composite of several potential routes. Perhaps the most significant is the "Greater Maumee River" as postulated by Ortmann and the Ohio Canal system. Other possible sources are in the form of an exchange of species through later connections of the St. Marys and Wabash River by means of dicthes and floodwaters. Furthermore there is a possibility of stream piracy among all headwater streams bringing about an open route to the Ohio River through its tributaries.

4. The distribution and abundance of naiades in Auglaize County is determined in part by ecological and habitat conditions.

5. Drastic changes in the ecology of the aqautic conditions in this county have without doubt resulted in the reduction or extermination of some species, an increase of others, and perhaps an addition of new inhabitants.

6. Erosion silt and the increasing irregularity of stream flow are the most detrimental factors to our mussel fauna.

7. Those species which are tolerant of the most widely diversified conditions are the most abundant in Auglaize County.

8. The mud-inhabiting species or those most tolerant of highly turbid waters are the ones which will probably continue to increase under existing conditions.

9. The mussels of Auglaize County have little economic importance and no mussel fishery can be anticipated.

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PRELIMINARY ANNOUNCEMENT

SYMPOSIUM ON PREMEDICAL EDUCATION

A. A. A. S. Meeting, Cleveland, Ohio

Alpha Epsilon Delta, national honorary pre-medical fraternity, is arranging a special program on Premedical Education to be held on Thursday, September 14th, during the A. A. A. S. meeting in Cleveland. The influence of the war and the accelerated training program upon postwar plans for premedical education will be among the major topics for discussion.

Dr. Victor Johnson, Secretary, the Council on Medical Education and Hospital of the American Medical Association; Dr. Carlos Reed, professor of physiology, University of Illinois, and Dr. H. E. Setterfield, premedical adviser, School of Medicine, Ohio State University, and president of Alpha Epsilon Delta, will be among the distinguished speakers. An informal round table discussion of problems and questions from the audience will follow the talks. All premedical teachers, especially those in colleges not associated with medical schools, are urged to attend. It is hoped that many teachers in non-science fields will attend also. Final announcement of the time and place will appear in the program of the meeting.

STUDIES IN THE BIOLOGY OF THE LEECH.[1] VIII.

Modifications in Neurological Microtechnique

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During the last two decades of the nineteenth century there were devised several basic methods of neurological microtechnique.[2] These made possible the study of the minute structure of the nervous system. Many modifications of these and other techniques have been offered until, at the present, there are probably more variations in neurological methods than in any other. This multitude of divergent procedure is based upon necessity.

In the study of nervous tissue there are many variable factors which influence to a marked degree the cytological as well as histological results. A few of the better known variables are functional condition, structural differentiation, and age of the tissue. The taxonomic position of the organism must be considered, and in many instances, species variation taken into account. In addition, there are many imperfectly known factors demanding variations in procedure that can be determined only after extensive experimentation.

The methods designed to assist in the microscopical examination of the nervous system can be divided into two fundamental groups: the one spoken of as cytological, and the other as histological or anatomical. The former refers to those techniques which, by virtue of minute qualitative differentiating properties, make possible a study of the intimate structure of nerve cells, processes, and their supporting tissues. The latter, histological or anatomical, applies more particularly to the minute structure and composition of nervous tissue. In general this latter type of study is concerned with the architectural arrangement of nerve cells, their processes, and their connections with one another.

The interest in chordates, and more particularly in man, has inspired exhaustive research for adequate neurological methods applicable to this group. To a large extent the methods presented for the study in invertebrate nervous systems have been borrowed, and modified from vertebrate procedures. Exceptions to this were the contributions to invertebrate neurological microtechnique made by some of the early investigators, and their students.

Retzius, Cajal, and deCastro, Smallwood, Rogers, Ascoli, Sanchez, to mention only a few, have each presented numerous modifications in neurological methods. Each has contributed to the growing list of variable procedures employed in the demonstration of nerve elements. Each has presented techniques applicable to the particular field of investigation in which he worked. With all due respect to these and other technicians, problems in invertebrate neurological research have remained unanswered for want of adequate cytological and histological methods.

THE PROBLEM

The behavior of an animal is the result of stimuli acting upon a particular arrangement of anatomical structure under the physiological conditions existing at the time of stimulation. The determination of the histological character of the tissue involved is a necessary prerequisite to an analysis of the causal factors in

[1] *Haemopis marmoratis* (Say).
[2] These methods are reviewed in Lee, McClung and others.

behavior. The leech, *Haemopis marmoratis*, (Say) has been used for some time by the writer in studying various aspects of annelid behavior. With the exception of the description of the subepidermal nerve plexus (1933) the authors' reaction studies have, for the most part, been of an analytical nature. Certain conclusions derived from the study of behavior, have, by inference, implied the general pattern of the nervous system. The limited knowledge of the nervous system of this form is to a large extent due to inadequate cytological and histological methods. The writer employing certain well founded principles of neurological procedure presents the following new methods and modifications.

NEUROLOGICAL METHODS

The methods used and the results obtained, as set forth in this paper, pertain specifically to the aforementioned animal. These procedures have not been tried on any other form. To what extent these methods may be applicable to other animals is a matter for further investigation. The discussion which follows should be considered with these points in mind.

RELAXING, KILLING, AND FIXING

These three steps in the preparation of the animal, and more particularly, the tissue to be studied, were considered as one operation. But inasmuch as variations were employed in each of the above, they will be presented separately. These were important details, for in many cases the success of the staining process was dependent upon these as well as subsequent treatments. The appearance of the tissue may be entirely altered by deviations from the prescribed methods.

Relaxing was the first step in the preparation of the leech for subsequent study. The three methods which were used are stated below. Each was employed in accordance with the killing and fixing procedure discussed later in this paper.

RELAXING METHODS

Method I. The leech was placed in a shallow glass dish containing a 0.1% to 0.2% solution of chloretone, to which had been added a pinch of proteolitic enzyme. (Caroid was found satisfactory). This latter, while not absolutely necessary, materially aided in disposing of the copious mucous secreted by the organism. After five minutes in the chloretone solution there was added, drop by drop, a saturated solution of the same, until the leech was completely relaxed. Dissection followed, or if the animal was to be imbedded in toto, it was straightened to normal size in a wax bottom dissecting pan, where it was held in position by pins. The first application of the killing and fixing agent was applied at this time.

Method II. Ether was an equally satisfactory relaxing agent. The leech was placed in a covered dish, into which was previously introduced a wad of cotton saturated with ether. In due time the animal was completely relaxed, and treated as stated in No. I.

Method III. This method differed from Method I or II, only in the anesthetic employed. In this method, alcohol was used in place of chloretone. Animals were prepared in this way when an alcoholic fixing medium was employed.

KILLING AND FIXING METHODS

Killing and Fixing procedure will be considered under one heading. While killing is usually referred to as the act of stopping all life processes and fixing a method of preserving the normal cell structure, the two steps should be accomplished simultaneously. Usually a single medium is employed for this purpose. If the nervous system is dissected prior to final fixation, great care should be exercised in the manipulation of the tissue. The same care should be taken if dissec-

tion is made following killing and fixing. As will be noted later in this paper, the staining methods employed and the results obtained are dependent to a large extent on this step.

Method I. A solution of 10% formalin was used to kill and fix either the dissected tissue, or the entire organism. The usual time of fixation was 24 hours. If no secondary fixing agent was employed following formalin fixation, washing in tap water for 5 minutes followed by several changes in distilled water was sufficient. If a secondary fixing solution was employed, the material was washed 5 hours or more in running water.

Method II. Bodian's No. 2 fixation was used with good results following either chloretone or alcohol relaxation. Bodian's was made by using 90 cc. of 90 per cent alcohol, plus 4 cc. commercial formalin plus 5 cc. acetic acid. The fixing period was 4 days.

Method III. Zenker's fixative was employed in the Masson technique. The material remained in the Zenker's solution for 10 hours; then washed an equal length of time in running water.

Method IV. Helly's fluid, a modification of Zenker's, in which the acetic acid in the latter was replaced by 5 per cent formalin, and used with Mallory's phosphotungstic acid in combination with hemotoxylin.

DEHYDRATION, CLEARING, INFILTRATION AND EMBEDDING

Dehydration was accomplished with the aid of alcohol alone, or in combination with dioxane. In order to expedite these standardized procedures, the leech was cut into three equal lengths. When the central nervous system had previously been dissected such portions were carried intact through these steps. The above processes may, depending on the procedure followed, precede or follow the basic staining technique.

DEHYDRATION METHODS (PARAFFIN METHOD)

Method I. The gradual removal of water was facilitated by alcohol, proceeding in the usual routine of passing the material through ascending grades. From 100 per cent alcohol the material was passed into a mixture of equal parts of 100 per cent alcohol and zylol. This procedure was employed on mounted sections of small pieces, after the use of an aqueous stain. For mounted sections the time in each of the lower grades of alcohol was 3 minutes; for 100 per cent alcohol and for half alcohol and half xylene the time was 5 minutes each, except where otherwise noted.

Method II. This was one of several procedures followed for dehydration prior to paraffin embedding. The properly killed and fixed specimen, or selected portion, was placed in 70 per cent alcohol for 3 hours. The tissue was then placed for 2 hours each in 83–90–95 per cent alcohol, respectively.

Method III. A third method used to prepare material for paraffin infiltration was as follows: The specimen, or part thereof, was placed in 70 per cent alcohol for 3 hours. Two changes were made in this grade. The tissue was then transferred to 100 per cent dioxane for 3 hours.

DEHYDRATION METHOD (CELLOIDIN)

Method IV. In the dehydration of material for celloidin embedding, it was necessary to insure absolute removal of all water. The following procedure proved to be adequate for parts of the nervous system, or sections of the animal. Beginning with 30 per cent alcohol, the material was carried through 50–70–80–95–100 per cent for a minimum of 2 hours each. Two changes of 2 hours each in absolute alcohol-ether completed this step.

CLEARING METHODS

Clearing is the process of removing the alcohol from the section or specimen and the substitution of a fluid miscible with paraffin. In this step the tissue becomes translucent. Variations in method and material used in this step were dependent upon the nature of the tissue, and their place in the operation as a whole.

In preparing a specimen for infiltration and embedding in paraffin, the first two methods given below were satisfactory. It is my observation that for *H. marmoratis*, method II gives less hardening with a minimum of shrinkage.

Method I. Immediately following dehydration, the specimen was placed in a mixture of one-half butyl alcohol and one-half soft (48°) paraffin. The specimen remained in this mixture over night in a closed dish in an oven of 58° C. At the end of 12 to 14 hours, the specimen was ready for further infiltration. This method was employed after dehydration method III.

Method II. Dehydration by method II was followed by placing the specimen in a mixture of one-half chloroform and one-half soft paraffin. In this medium, the specimen was allowed to remain over night in a closed dish at room temperature. Further infiltration followed the regular procedure outlined below.

Method III. In the clearing of mounted sections following dehydration carbol xylene or xylene was used. The usual procedure of employing at least two changes of xylene was followed.

Method IV. Sections previously embedded in celloidin were cleared in cedar wood oil before mounting.

INFILTRATION AND EMBEDDING

Infiltration is the process of replacing the clearing agent with the material in which the tissue is to be imbedded. It also refers to the gradual impregnation of the tissue by celloidin, in instances where this latter is employed as the supporting medium. This step was accomplished by gradually infiltrating the tissue building up to the required density or concentration of the supporting agent.

Paraffin Method (Infiltration). Following clearing methods I or II, the material was placed in soft paraffin for two hours. This was replaced by a mixture of half soft and half hard (58°) paraffin and returned to the oven for two hours. The same procedure was repeated using hard paraffin. If used paraffin was employed, it was followed by an addition change of two hours in fresh paraffin. The hard paraffin, being the so-called "rubber paraffin," had a melting point of 56°–58° C. This same grade was used in the embedding process.

Paraffin Method (Embedding). This is a process in which the tissue or specimen is enclosed in a hardened block of supporting medium. Paraffin and celloidin are the conventional agents employed. Following the infiltration process, embedding is the final step prior to sectioning. In this step, as in all others, practice and repeated trials prove to be the best guide.

Plaster of Paris boxes were the most satisfactory embedding forms used for the paraffin method. Plaster of Paris boxes were soaked in water a few minutes prior to the introduction of the paraffin. The specimen was transferred from the infiltrating medium by warmed forceps, oriented, imbedding paraffin added, and a label inserted. As soon as a film forms over the surface of the paraffin the entire preparation was immersed in ice water, the contraction of the paraffin freeing the block. Many specimens can be so embedded in a short time, using not more than two plaster of Paris boxes in rotation.

Celloidin Method (Infiltration and Embedding). Material to be infiltrated and embedded in celloidin was dehydrated according to method IV. Following dehydration, the tissue was placed in 10 per cent celloidin for eight hours, then left over

night in 15 per cent celloidin. The material to be mounted was supported by a block of hardened celloidin, and oriented within a mould formed by surrounding the fiber cutting block with gummed paper. The cutting block mould was then filled with 15 per cent celloidin; the tissue oriented and hardened under a bell jar. Chloroform was used to complete the hardening. After a few hours the block was placed in thin cedar wood oil, where it remained until sectioned. It must be kept in mind for the above outlined procedure that the block of tissue was small.

The celloidin method of infiltration and embedding was the most satisfactory procedure where thick sections were desired. The celloidin method is particularly suitable for large tissue masses, but, in such instances infiltration and embedding may take days, or even weeks. It is essential that the tissue be infiltrated *gradually* and hardened slowly. Cedar wood oil was used in preference to alcohol during the cutting process. Sections were then cleared in thin cedar wood oil until further treatment.

STAINING METHODS

As previously stated, the writer was interested principally in behavior studies involving the neuro-anatomy of the leech. The application of neurological methods served only as a means toward the proposed objective. With all of the facilities of the Department of Anatomy of the Ohio State University at the writer's disposal, the initial project was begun. With the encouragement of the teaching staff and the able counsel of the Department's technician, many previously described methods were tried, none of which gave the desired results. It must not be inferred from this that the following tried and proven techniques failed entirely. On the contrary, thousands of sections proved extremely interesting. But in none of these, using the following basic procedures, were the desired elements sufficiently differentiated. The following are a few of the basic procedures first tried and later modified.

1. Activated protargol, D. Bodian.
2. Modified protargol, D. Bodian.
3. Formol thionin.
4. Methods I, II, III, and IV, (S. R. Cajal and deCastrol), Micro. Tech., McClung, 1937.
5. Iron hematoxylin.
6. Kopsch Golgi method.
7. N. C. Foot's modified Bielschowsky.
8. Ammoniated silver modification of J. W. Kernohan.
9. Masson technique.
10. Mallory's phosphotungstic acid and hematoxylin technique.
11. Ranson's pyridine silver method.

MILLER'S METHOD

The outlined procedure which follows was presented in detail by Miller (1944). This method combines several basic principles of neurological technique. Although it is a lengthy procedure it gives excellent differentiation to leech material. Sections prepared by this method are useful in both histological or cytological study.

The following outline denotes each step in the procedure:

1. Animal relaxed according to method I.
2. Killed and fixed as described in method I.
3. Nervous system dissected. A ventral strip of body wall may be left attached for convenience in orientation. A completely dissected nerve trunk was pinned on a strip of heavy paper bent to form a bow.
4. Tissue immersed in 3% potassium dichromate two weeks.
5. Rinsed in several changes of distilled water.
6. Tissue placed in 1% solution of silver nitrate; after precipitate forms, transfer to fresh 1% solution silver nitrate for one week.
7. Rinsed in several changes of distilled water.
8. Dehydrated, infiltrated and embedded as directed in preparation of celloidin sections.

9. Sections cut to desired thickness.
10. Sections transferred to thin cedar wood oil. This may be left here until clear, or until ready to proceed. Sections can be kept serially by separators.

At this point, two alternative procedures were followed—(A or B).

11A. Sections gradually hydrated and placed in
12A. Six per cent silver nitrate solution for four days (in dark).
13A. Washed in several changes of distilled water.
14A. Reduced for 24 hours in the following mixture (in dark):

Hydroquinone	2.0 g.
Neutral formalin	20.0 cc.
Water (distilled)	200.0 cc.

15A. Washed in several changes of distilled water.
16A. (Optional) Tone in 0.2% gold chloride, 30 minutes.
17A. Washed in distilled water.
18A. Fixed in 5% hypo-sulphite of soda, 30 seconds.
19A. Washed in distilled water. (Counter stain at this point if desired.)
20A. Dehydrated, cleared, mounted in clarite.

Optional Procedure:

11B. Sections from cedar wood oil were gradually hydrated then placed in
12B. 20% silver nitrate solution, 1 hour to 1½ hours.
13B. Washed quickly in distilled water and placed in
14B. Ammoniated silver nitrate, 3 minutes. This was prepared by adding concentrated aqua ammonia drop by drop to 20% silver nitrate solution until ppt. is almost dissolved and then filtered. This must be freshly prepared, and can be used but once.
15B. Washed quickly in distilled water.
16B. Sections placed in 10% formalin 1 minute.
17B. Washed in several changes of distilled water.
18B. Tone in 2.0% gold chloride, 10 minutes.
19B. Washed in distilled water.
20B. Optional procedure: Reduce in 2.0% oxalic acid plus 1 cc. formalin per 100 cc. of solution, 20 seconds.
21B. Washed in distilled water.
22B. Fixed in 5% hypo-sulphite of soda, 2 minutes.
23B. Washed in distilled water (counter stain at this point if desired).
24B. Dehydrated, cleared, mounted in clarite.

A counter stain was used successfully following either of the above variations. Mayer's acid hematoxylin and eosin, or Mayer's haemalum gave good cellular differentiation. Mallory's phosphotungstic acid hematoxylin as a counter stain was very effective following either of the above variations. Standard procedures were followed for counter staining and subsequent treatment.

Method A produced the best material for histological study, particularly with reference to the longitudinal and frontal sections. Method B was especially useful in cytological study, being particularly valuable in sections through ganglia. Both variations were equally satisfactory for general morphological studies.

OTHER METHODS

In the course of this study many different techniques were employed. There were several which gave good supplementary results. In most instances, modifications from established procedures were necessary in adapting the technique to leech material. At this point the writer wishes to emphasize the importance of

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Explanation of Plate I

Fig. 1. Photomicrograph—Method IV. Modification A. "Gross" nerve cell in supra-esophageal ganglion.
Fig. 2. Photomicrograph—Miller's Method A. Frontal section through ganglion.
Fig. 3. Photomicrograph—Method II. Cross-section through mid-body ganglion.

1

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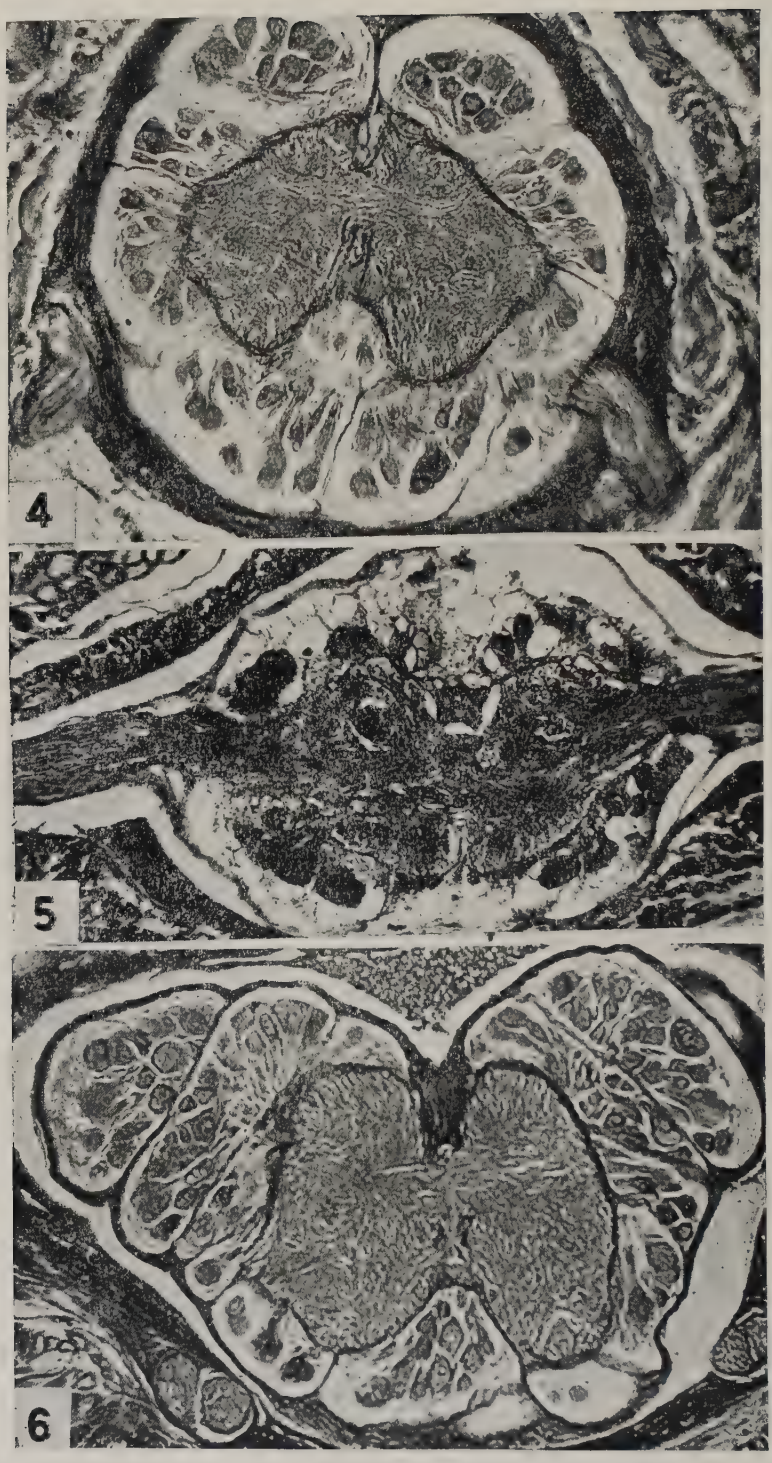
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5
6

employing a variety of techniques when undertaking a comprehensive study. This necessitates the employment of diverse methods. In the study of no other tissue are these factors more important. Each new variation in technique supplements, rather than displaces, an established procedure. Each series adds its contribution to the total picture. The procedures which follow were found to be the most applicable, and the preparations the most usable.

I. Cajal-deCastro modification.

1. Relax animal according to method III.
2. Kill and fix in ammoniated absolute alcohol, 24 hours; *14 drops concentrated ammonia* to 100 cc. alcohol.
3. Dissect nervous system, then wash in 50% alcohol.
4. Place tissue in 6% silver nitrate, 72 hours, at 37° C., in dark.
5. Wash in distilled water.
6. Reduce 24 hours in dark in

10% neutral formalin	20 cc.
Hydroquinone	2 gm.
Distilled water	200 cc.

7. Wash in several changes of distilled water.
8. Tone in 0.2% gold chloride, 30 minutes.
9. Wash in several changes of distilled water.
10. Fix in 5% hyposulphite of soda, 30 seconds.
11. Wash in several changes of distilled water.
12. Dehydrate, as directed in method II.
13. Clear as in method II.
14. Infiltrate and embed by method I.
15. Section.
16. Clear as stated in method III.
17. Mount in clarite.

It will be noted that the amount of ammonia may be varied according to the specific nature of the nervous system used. Too much ammonia has a tendency to produce a faded out picture. It was noted that in sections containing both cerebral ganglia and ventral nerve cord, the two regions were not equally impregnated.

II. Bielschowsky modification.

1. Relax animal according to method I.
2. Kill and fix as described in method I, II, and IV. (Series employing each fixative.)
3. Dehydrate, method II, III.
4. Clear, method I and II.
5. Infiltrate and embed, method I.
6. Section, 10μ.
7. Mount, remove paraffin, and gradually hydrate.
8. Wash in distilled water.
9. Place slides in 20% silver nitrate, one hour at room temperature.
10. Wash quickly in distilled water (two dips in each of two changes) and place in
11. Ammoniated silver nitrate prepared as in 14B, Miller's Method.
12. Wash quickly in distilled water.
13. Sections to 10% formalin, 30 seconds.
14. Wash in distilled water; several changes.
15. Tone in 0.2% gold chloride, 20 minutes.
16. Wash in distilled water.
17. Reduce in 2.0 oxalic acid, plus 1 cc. of 40% formalin per 100 cc. of solution, 30 seconds.
18. Wash in distilled water.
19. Fix in 2.0% hyposulphite of soda, 2 minutes.
20. Wash in several changes of distilled water.
21. Dehydrate, method I.
22. Clear, method III.
23. Mount in clarite.

EXPLANATION OF PLATE II

FIG. 4. Photomicrograph—Method III. Cross-section through caudal ganglion.
FIG. 5. Photomicrograph—Method I. Cross-section through mid-body ganglion.
FIG. 6. Photomicrograph—Method III. Cross-section through subesophageal ganglion.

III. Masson stain.

This standard stain technique was used with variations as indicated in the following:

1. Relaxing, method I.
2. Killing and fixing, method II and III.
3. Dehydration, method II.
4. Clearing, method II.
5. Infiltration and embedding, method I.
6. Section, mount and remove paraffin.
7. Gradual hydration, stain 5 minutes in Mayer's haemalum.
8. Rinse in distilled water, wash in tap water until blue, and return to distilled water.
9. Stain 5 minutes in
   2 pints ponceau de xylidine 1% In 1% acetic acid in
   1 pint Acid fuchsin distilled water.
10. Rinse in distilled water, 2 changes.
11. Mordant 5 minutes in 5% phosphotungstic acid.
12. Rinse in distilled water.
13. Stain 5 minutes in 2% aniline blue in 2% acetic acid.
14. Rinse in distilled water.
15. Sections to 1% acetic acid, 5 minutes.
16. Sections transferred to distilled water, then
17. Direct to 95% alcohol. Differentiate in 95%. Several changes; if stain is light pass through quickly. If blue has overstained, place slides in 70% alcohol overnight and restain.
18. Five minutes in half absolute and half xylene.
19. Xylene; two changes, each 5 minutes.
20. Mount in clarite.

It will be noted that there are several minor changes from the regular routine, particularly with reference to the killing and fixing procedure. This stain gave excellent cellular and tissue differentiation.

IV. Mallory's phosphotungstic acid hematoxylin method.

Modifications in this technique were largely confined to variations in killing and fixing procedure. This method provided a valuable series of sections illustrating not only the intra-cellular fibrils, but cytological details of ganglion cells. Mallory and Parker in McClung have described the preparation of the stain and certain prescribed steps. Leech material was prepared by the writer using the following combinations of relaxing, killing, and fixing methods followed by paraffin embedding.

1A. Relax by method I, kill and fix, method I.
2A. Dehydrate by method III, clear, method I, embed, method I.
1B. Relax by method III, kill and fix, method II.
2B. Dehydrate, method II, clear, method II, embed, method I.
1C. Relax by method I, kill and fix, method IV.
2C. Dehydrate, method II, clear, method II, embed, method I.

For the convenience of the reader, the following condensed outline of the routine procedure as given by McClung follows:

1. Sections hydrated (if Helly's fixative was used, treat sections in 70% to which has been added iodine) 0.4% iodine in 70% alcohol, 3 minutes. Bleach and wash in 0.25% sodium hyposulphate, 3 minutes. Wash in 70% or 50%, 5 minutes. Sections passed through 35% to distilled water.
2. Sections to 0.25% aqueous solution of potassium permanganate, 10 minutes.
3. Wash in several changes of distilled water.
4. Sections to 5% oxalic acid, 20 minutes.
5. Wash thoroughly in several changes of distilled water.
6. Stain 20–24 hours in Mallory's phosphotungstic acid, hematoxylin.
7. Sections direct to 95% alcohol (quick).
8. Sections to absolute (quick).
9. Sections to absolute and xylene, 50–50.
10. Sections to xylene, 2 changes.
11. Mount in clarite.

It will be noted that this procedure follows the recommendations of Mallory, with the exception of the killing and fixing agents employed, and the special treatment following Helly's fixative.

V. Formal thionin technique as applied to the leech.

1. Relax by method II.
2. Kill, fix and stain, 26 days in the following:
   .25% thionin.
   10% formalin.
3. Dehydrate in dioxane, 3 changes of 3 hours each.
4. Clear by method I.
5. Infiltrate and embed by method I.
6. Section, mount, remove paraffin in two changes of xylene (five minutes), add clarite and cover slip.

The sections so prepared are usable in general morphological study. It is not intended the thionin be presented as a neurological stain. It produces, however, a pleasing picture of the general morphology of the tissue, and is extremely useful in orientation.

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Statistical Adjustment

This book appears to be destined to exert considerable influence on the statistical analysis of data gathered in the industrial, economic, sociological, and biological fields. The emphasis, as the title suggests, is throughout placed upon the adjustment of observed data by the method of "least squares." The author demonstrates the wide applicability of this method, first by introducing a few simple illustrations, next by developing the fundamental theory, and finally by considering conditions without and conditions with parameters. Throughout, systematic computing forms are included to enable a user of the method of least squares to reach a numerical conclusion efficiently—a conclusion that may be used for action.

This volume may be used as a text in advanced courses in statistical methods, but is likely to find greater usefulness among research workers and practicing statisticians. As a novelty, the case in which both x and y observations are subject to error is discussed and illustrated as the second of four examples appended at the close of the formal development.

The author has spent sixteen years in the government service, in the Bureau of the Census and the Bureau of the Budget, and has had opportunity to test in practice the methods outlined in this book.—*E. L. Green.*

Statistical Adjustment of Data, by W. Edwards Deming. x+261 pp. 24 figs. New York, John Wiley and Sons. 1943. $3.50.

ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. XII.[1]

CLYDE H. JONES,
The Ohio State University

In spite of travel restrictions, amateur botanists throughout the State have contributed their usual number of specimens to the Herbarium during the past year. Unfortunately, some collections have remained unexamined due to the lack of "man-power" for assistance and to the temporary assignment of herbarium personnel to the teaching of Army classes on the campus. The Curator, however, wishes to thank the numerous collectors for their continued interest and promises a report in detail on their contributions as soon as time and assistance permit.

Without doubt the most important single acquisition of the year is the L. S. Hopkins pteridophyte herbarium consisting of approximately 6200 specimens in excellent condition. In addition, Mr. Hopkins has contributed over 500 specimens representing other families. This latter collection consists for the most part of specimens from the northeastern counties of Ohio. It is particularly valuable as many of the habitats in which these plants were found have since been destroyed.

H. W. Rickett, of the New York Botanical Garden, an authority on the *Cornaceae*, has examined our *Cornaceae* collections and suggested various changes in identification and nomenclature. These changes and the distribution of species by counties are included in their proper numerical position in this report.

Certain entries in the following list of additions are cited by location only, the collector's name being omitted. Such specimens were collected by John N. Wolfe, Richard T. Wareham, and Herbert T. Scofield in the Sugar Grove region during the past five years in connection with their study of the microclimates of that area. To date they have contributed 76 county records, herein recorded for the first time.

The following list of plants represents a majority of the new county and state records which have been added to the State Herbarium during the past year.

7. *Botrychium virginianum* (L.) Sw. Virginia Grape-fern. Good Hope Twp., Hocking Co.
10. *Osmunda cinnamomea* L. Cinnamon-fern. Good Hope Twp., Hocking Co.
27.1. *Asplenium bradleyi* D. C. Eaton. Bradley's Spleenwort. Jackson Twp., Pike Co. Floyd Bartley.
56. *Equisetum nelsoni* (A. A. Eat.) Schaffn. Nelson's Scouring-rush. Ashtabula Co. L. E. Hicks.
61. *Equisetum arvense* L. Field Horsetail. Good Hope Twp., Hocking Co.
101.1. *Potamogeton crispus* L. Curly Pondweed. Buckeye Lake, Licking Co. State Department of Conservation via G. W. Blaydes.
129. *Spathyema foetida* (L.) Raf. Skunk-cabbage. Good Hope Twp., Hocking Co.
130. *Peltandra virginica* (L.) Kunth. Green Arrow-arum. Good Hope Twp., Hocking Co.
140. *Scirpus lineatus* Mx. Reddish Bulrush. Wayne Co. L. S. Hopkins.
142. *Scirpus sylvaticus* L. Wood Bulrush. Wayne Co. L. S. Hopkins.
145.2. *Scirpus occidentalis* (Matson) Chase. Viscid Great Bulrush. Ashland Co. L. S. Hopkins.
148. *Scirpus americanus* Pers. Chair-maker's Rush. Medina Co. L. S. Hopkins.
165. *Eleocharis obtusa* (Willd.) Schultes. Blunt Spikerush. Good Hope Twp., Hocking Co.
176. *Cyperus esculentus* L. Nut-grass. Hocking Twp., Fairfield Co. Charles R. Goslin.
398. *Sporobolus cryptandrus* (Torr.) Gr. Sand Dropseed. Lake Co. L. E. Hicks.
409. *Cinna arundinacea* L. Wood Reed-grass. Highland Co. L. S. Hopkins.
442.1. *Aegilopsis cylindrica* Host. Jointed Goatgrass. Cincinnati, Hamilton Co. Loise Clermont.

[1]Papers from the Department of Botany, The Ohio State University, No. 470.

455. *Capriola dactylon* (L.) Ktz. Bermuda-grass. Pickaway Co. C. J. Willard.
460. *Homalocenchrus virginicus* (Willd.) Britt. Virginia Cut-grass. Highland Co. L. S. Hopkins.
467. *Panicum dichotomiflorum* Mx. Spreading Panic-grass. Medina Co. L. S. Hopkins.
483. *Panicum polyanthes* Schultes. Many-flowered Panic-grass. Belmont Co. Emma E. Laughlin.
489. *Panicum tennesseense* Ashe. Tennessee Panic-grass. Wayne Co. L. S. Hopkins.
494. *Panicum implicatum* Scribn. Slender-stemmed Panic-grass. Wayne Co. L. S. Hopkins.
495. *Panicum commutatum* Schultes. Variable Panic-grass. Wayne Co. L. S. Hopkins.
496. *Panicum clandestinum* L. Hispid Panic-grass. Wayne Co. L. S. Hopkins.
503. *Echinochloa crus-galli* (L.) Beauv. Common Barnyard-grass. Highland Co. L. S. Hopkins.
535. *Allium vineale* L. Field Garlic. Seneca Co. Kenneth Rinehart via C. J. Willard.
537. *Allium sibiricum* L. Siberian Chives. Franklin Co. C. J. Willard.
561. *Trillium sessile* L. Sessile Trillium. Perry Co. Floyd and Elizabeth Clum.
564. *Uvularia perfoliata* L. Perfoliate Bellwort. Good Hope Twp., Hocking Co.
565. *Uvularia grandiflora* Sm. Large-flowered Bellwort. Good Hope Twp., Hocking Co.
570. *Polygonatum biflorum* (Walt.) Ell. Hairy Solomon's-seal. Good Hope Twp., Hocking Co.
579. *Smilax scirrhata* (Engelm.) Wats. Upright Smilax. Good Hope Twp., Hocking Co.
628. *Iris virginica* L. Virginia Blue-flag. Good Hope Twp., Hocking Co.
639. *Galeorchis spectabilis* (L.) Rydb. Showy Orchis. Good Hope Twp., Hocking Co.
665. *Isotria verticellata* (Willd.) Raf. Whorled Isotria. Tar Hollow, Ross Co. Clyde H. Jones.
668. *Liparis loeselii* (L.) Rich. Fen Twayblade. Tar Hollow, Ross Co. Ethel Harper.
670. *Aplectrum hyemale* (Muhl.) Torr. Putty-root. Good Hope Twp., Hocking Co.
681. *Ranunculus abortivus* L. Kidney-leaf Crowfoot. Perry Co. Floyd and Elizabeth Clum. Good Hope Twp., Hocking Co.
690. *Ranunculus hispidus* Mx. Hispid Buttercup. Good Hope Twp., Hocking Co.
693. *Ranunculus obtusiusculus* Raf. Lance-leaf Buttercup. Wayne Co. L. S. Hopkins.
750. *Sanguinaria canadensis* L. Bloodroot. Perry Co. Floyd and Elizabeth Clum. Good Hope Twp., Hocking Co.
754. *Bicuculla cucullaria* (L.) Millsp. Dutchman's-breeches. Perry Co. Floyd and Elizabeth Clum.
762. *Berteroa incana* (L.) DC. Hoary Berteroa. Lake Co. Fred Tyler.
765. *Draba verna* L. Vernal Whitlow-grass. Good Hope Twp., Hocking Co.
793. *Cheirinia inconspicua* (Wats.) Britt. Prairie Cheirinia. Athens Co. Walter P. Porter and P. S. Wamsley.
809. *Arabis glabra* (L.) Bernh. Tower Mustard. Hocking Twp., Fairfield Co. Charles R. Goslin.
826. *Dentaria laciniata* Muhl. Cutleaf Toothwort. Good Hope Twp., Hocking Co.
857. *Oxalis stricta* L. Upright Wood-sorrel. Good Hope Twp., Hocking Co.
861. *Oxalis corniculata* L. Procumbent Wood-sorrel. Wayne Co. L. S. Hopkins.
863. *Oxalis violacea* L. Violet Wood-sorrel. Good Hope Twp., Hocking Co.
873. *Impatiens biflora* Walt. Spotted Touch-me-not. Berne Twp., Fairfield Co. Charles R. Goslin.
882. *Polygala viridescens* L. Purple Milkwort. Good Hope Twp., Hocking Co.
890.1. *Croton glandulosus* L. Glandular Croton. Adams Co. Conrad Roth.
907. *Chamaesyce preslii* (Guss.) Arth. Nodding Spurge. Good Hope Twp., Hocking Co.
908. *Chamaesyce humistrata* (Engelm.) Small. Hairy Spreading Spurge. Medina Co. L. S. Hopkins.
964. *Viola eriocarpa* Schw. Smooth Yellow Violet. Good Hope Twp., Hocking Co.
971.1. *Viola arvensis* Murr. European Field Pansy. Belmont Co. Emma E. Laughlin. Adams Co. Conrad Roth.
980. *Viola papilionacea* Pursh. Common Blue Violet. Good Hope Twp., Hocking Co.
988. *Viola sagittata* Ait. Arrow-leaf Violet. Adams Co. John N. Wolfe.
1001. *Alsine media* L. Common Chickweed. Good Hope Twp., Hocking Co.
1018. *Silene stellata* (L.) Ait. f. Starry Campion. Good Hope Twp., Hocking Co.
1038. *Claytonia virginica* L. Spring-beauty. Good Hope Twp., Hocking Co.
1043. *Phytolacca americana* L. Pokeweed. Good Hope Twp., Hocking Co.
1065. *Chenopodium boscianum* Moq. Bosc's Goosefoot. Greenfield Twp., Fairfield Co. Charles R. Goslin.
1074. *Atriplex hastata* L. Halberd-leaf Orache. Hocking Twp., Fairfield Co.
1080. *Steironema ciliatum* (L.) Raf. Fringed Yellow Loosestrife. Good Hope Twp., Hocking Co.
1114. *Persicaria punctata* (Ell.) Small. Dotted Smartweed. Good Hope Twp., Hocking Co.
1123. *Polygonum aviculare* L. Doorweed. Hocking Twp., Fairfield Co. Charles R. Goslin.

1129. *Geum canadense* Jacq. White Avens. Good Hope Twp., Hocking Co.
1179. *Agrimonia parviflora* Sol. Small-flowered Agrimonia. Good Hope Twp., Hocking Co.
1248. *Trifolium agrarium* L. Yellow Hop Clover. Wayne Co. L. S. Hopkins.
1287. *Meibomia grandiflora* (Walt.) Ktz. Pointed-leaf Tick-trefoil. Good Hope Twp., Hocking Co.
1325. *Strophostyles helvola* (L.) Britt. Trailing Wild Bean. Belmont Co. Emma E. Laughlin.
1330. *Sedum ternatum* Mx. Wild Stonecrop. Good Hope Twp., Hocking Co.
1331. *Penthorum sedoides* L. Ditch Stonecrop. Good Hope Twp., Hocking Co.
1366. *Parthenocissus quinquefolia* (L.) Planch. Virginia Creeper. Good Hope Twp., Hocking Co.
1386. *Acer saccharinum* L. Silver Maple. Good Hope Twp., Hocking Co.
1387. *Acer negundo* L. Boxelder. Good Hope Twp., Hocking Co.
1417. *Fagus grandifolia* Ehrh. American Beech. Good Hope Twp., Hocking Co.
1431. *Quercus coccinea* Wang. Scarlet Oak. Good Hope Twp., Hocking Co.
1432. *Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe. Red Oak. Tar Hollow, Ross Co. Clyde H. Jones.
1433. *Quercus palustris* Du Roi. Pin Oak. Greenfield Twp., Fairfield Co. Charles R. Goslin.
1438. *Betula lutea* Mx. f. Yellow Birch. Revenge, Fairfield Co.
1452. *Juglans nigra* L. Black Walnut. Good Hope Twp., Hocking Co.
1453. *Juglans cinerea* L. Butternut. Good Hope Twp., Hocking Co.
1470. *Salix vitellina* L. Yellow Willow. Tar Hollow, Ross Co. Clyde H. Jones.
1493. *Grossularia cynosbati* (L.) Mill. Prickly Gooseberry. Perry Co. Floyd and Elizabeth Clum.
1532. *Asarum canadense* L. Canadian Wild Ginger. Good Hope Twp., Hocking Co.
1555. *Hypopitys americana* (DC) Small. Smooth Pinesap. Tar Hollow, Ross Co. Arthur R. Harper.
1579. *Phlox divaricata* L. Wild Blue Phlox. Good Hope Twp., Hocking Co.
1619. *Fraxinus biltmoreana* Bead. Biltmore's Ash. Tar Hollow, Ross Co. Clyde H. Jones.
1629. *Gentiana flavida* Gr. Yellow Gentian. Bear Creek, Scioto Co. Don Durnell via John N. Wolfe.
1637. *Apocynum medium* Greene. Intermediate Dogbane. Wayne Co. L. S. Hopkins.
1646. *Asclepias incarnata* L. Swamp Milkweed. Good Hope Twp., Hocking Co.
1671. *Physalis heterophylla* Nees. Clammy Ground-cherry. Wayne Co. L. S. Hopkins.
1678. *Solanum nigrum* L. Black Nightshade. Cedar Falls, Hocking Co. John N. Wolfe.
1682. *Verbascum blattaria* L. Moth Mullen. Good Hope Twp., Hocking Co.
1693. *Chelone montana* var. *elatior* (Raf.) P. & W. Mountain Turtle-head. Fairfield Co.
1696. *Collinsia verna* Nutt. Blue-eyed-Mary. Pleasant Twp., Fairfield Co. Velma Beougher via Charles R. Goslin.
1740. *Chaenorrhinum minus* (L.) Lange. Lesser Toadflax. Berne Twp., Fairfield Co. Charles R. Goslin.
1767. *Lappula virginiana* (L.) Greene. Virginia Stickseed. Good Hope Twp., Hocking Co.
1787. *Verbena urticaefolia* L. White Vervain. Good Hope Twp., Hocking Co.
1793. *Lippia lanceolata* Mx. Frog-fruit. Hocking Co.
1799. *Teucrium occidentale* Gr. Hairy Germander. Wayne Co. L. S. Hopkins.
1820. *Mentha canadensis* L. American Wild Mint. Medina Co. L. S. Hopkins.
1823. *Lycopus virginicus* L. Virginia Water-hoarhound. Hocking Co.
1824. *Lycopus uniflorus* Mx. Northern Water-hoarhound. Good Hope Twp., Hocking Co.
1828. *Koellia flexuosa* (Walt.) MacM. Narrow-leaf Mountain-mint. Licking Co. H. E. Eswine.
1870. *Blephilia hirsuta* (Pursh.) Torr. Hairy Blephilia. Hocking Co.
1902. *Deringa canadensis* (L.) Ktz. Honewort. Good Hope., Hocking Co.

Cornaceae. Dogwood Family

1935. *Cornus alternifolia* L. f. Blue Dogwood. Greene, Clark, Champaign, Highland, Adams, Scioto, Ross, Pickaway, Franklin, Jackson, Hocking, Fairfield, Licking, Knox, Morrow, Richland, Huron, Erie, Lorain, Wayne, Coshocton, Muskingum, Meigs, Noble, Monroe, Belmont, Harrison, Jefferson, Carroll, Stark, Summit, Cuyahoga, Lake, and Ashtabula Counties.
1936. *Cornus amomum* Mill. Silky Dogwood. Defiance, Adams, Jackson, Meigs, Hocking, Licking, Stark, Medina, and Trumbull Counties.
1936.1. *Cornus purpusi* Koehne (*C. obliqua*). Oblique Dogwood. Montgomery, Greene, Fayette, Clark, Champaign, Logan, Auglaize, Williams, Lucas, Franklin, Fairfield, Coshocton, Wayne, Richland, Huron, and Ashtabula Counties.
1936.2. *Cornus amomum* Mill. x *C. purpusi* Koehne. Clark, Scioto, Franklin, Fairfield, Coshocton, Stark, Summit, Erie, and Ottawa Counties.

1937. *Cornus drummondi* Meyer. (This species has long been known as *C. asperifolia*, which is a species of the southeastern coastal plains.) Drummond's Dogwood. Hamilton, Clermont, Adams, Lawrence, Butler, Warren, Ross, Montgomery, Pickaway, Greene, Morgan, Miami, Clark, Madison, Franklin, Licking, Muskingum, Shelby, Logan, Knox, Coshocton, Auglaize, Hardin, Lucas, Wood, Ottawa, Erie, Lorain and Cuyahoga Counties.
1938. *Cornus rugosa* Lam. Roundleaf Dogwood. Warren, Ross, Lorain, Cuyahoga, Summit, Geauga, Lake, and Ashtabula Counties.
1939. *Cornus racemosa* Lam. (*C. paniculata, C. femina, C. candidissima*). Racemed Dogwood. Van Wert, Defiance, Williams, Fulton, Lucas, Wood, Hancock, Hardin, Clark, Clinton, Highland, Adams, Ross, Hocking, Fairfield, Delaware, Wyandot, Muskingum, Coshocton, Richland, Erie, Lorain, Wayne, Belmont, Tuscarawas, Carroll, Stark, Cuyahoga, Geauga, and Lake Counties.
1940. *Cornus stolonifera* Mx. Red-osier Dogwood. Lucas, Huron, Stark, Summit, Cuyahoga, Lake, and Ashtabula Counties.
1941. *Cornus florida* L. (*Cynoxylon floridum*). Flowering Dogwood. Williams, Fulton, Defiance, Lucas, Logan, Auglaize, Miami, Clark, Preble, Montgomery, Greene, Butler, Warren, Hamilton, Clermont, Brown, Adams, Scioto, Highland, Pike, Jackson, Gallia, Ross, Vinton, Hocking, Fairfield, Franklin, Licking, Delaware, Morgan, Morrow, Wyandot, Richland, Huron, Lorain, Cuyahoga, Medina, Summit, Stark, Wayne, Holmes, Tuscarawas, Washington, Noble, Monroe, Belmont, Harrison, Carroll, Columbiana, and Trumbull Counties.
1942. *Cornus canadensis* L. (*Cynoxylon canadense*). Bunchberry or Dwarf Dogwood. Licking, Stark, Portage, Geauga, Lake, and Ashtabula Counties.

1951. *Cephalanthus occidentalis* L. Buttonbush. Good Hope Twp., Hocking Co.
1959. *Galium lanceolatum* Torr. Lanceleaf Wild Licorice. Hocking Twp., Fairfield Co. Charles R. Goslin.
2013. *Campanula aparinoides* Pursh. Marsh Bellflower. Good Hope Twp., Hocking Co.
2019. *Lobelia inflata* L. Indian Tobacco. Good Hope Twp., Hocking Co.
2030. *Heliopsis helianthoides* (L.) Sw. Smooth Oxeye. Good Hope Twp., Hocking Co.
2038. *Rudbeckia triloba* L. Thin-leaf Cone-flower. Good Hope Twp., Hocking Co.
2039. *Rudbeckia laciniata* L. Tall Cone-flower. Wayne Co. L. S. Hopkins.
2072. *Bidens laevis* (L.) B. S. P. Smooth Bur-marigold. Good Hope Twp., Hocking Co.
2073. *Bidens cernua* L. Nodding Bur-marigold. Good Hope Twp., Hocking Co.
2080.1. *Bidens involucrata* (Nutt.) Britt. Long-bracted Tickseed. Valley of the Hocking River, Athens Co. P. S. Wamsley and Walter P. Porter.
2112. *Antennaria plantaginifolia* (L.) Rich. Plantain-leaf Everlasting. Good Hope Twp., Hocking Co.
2128. *Solidago rigidiuscula* (T. & G.) Port. Slender Showy Goldenrod. Good Hope Twp., Hocking Co.
2134. *Solidago ulmifolia* Muhl. Elmleaf Goldenrod. Geauga Co. L. S. Hopkins.
2150. *Aster shortii* Hook. Short's Aster. Hocking Co. Warren Jacobs.
2151. *Aster azureus* Lindl. Azure Aster. Hocking Co. Warren Jacobs.
2152. *Aster cordifolius* L. Common Blue Wood Aster. Hocking Co. Warren Jacobs.
2153. *Aster lowrieanus* Port. Lowrie's Aster. Hocking Co.
2157. *Aster undulatus* L. Wavy-leaf Aster. Fairfield Co.
2158. *Aster puniceus* L. Purple-stem Aster. Good Hope Twp., Hocking Co.
2163. *Aster prenanthoides* Muhl. Crooked-stem Aster. Hocking Co. Warren Jacobs.
2164. *Aster laevis* L. Smooth Aster. Hocking Co.
2165. *Aster concinnus* Willd. Narrow-leaf Smooth Aster. Hocking Co. Warren Jacobs.
2167. *Aster lateriflorus* (L.) Britt. Starved Aster. Good Hope Twp., Hocking Co.
2169. *Aster vimineus* Lam. Small White Aster. Hocking Co. Warren Jacobs.
2174. *Aster tradescanti* L. Tradescant's Aster. Good Hope Twp., Hocking Co.
2179. *Erigeron philadelphicus* L. Philadelphia Fleabane. Good Hope Twp., Hocking Co.
2180. *Erigeron ramosus* (Walt.) B. S. P. Daisy Fleabane. Good Hope Twp., Hocking Co.
2184. *Doellingeria umbellata* (Mill.) Nees. Tall Flat-top Aster. Wayne Co. L. S. Hopkins.
2195. *Eupatorium aromaticum* L. Smaller Snake-root. Good Hope Twp., Hocking Co.
2204. *Vernonia altissima* Nutt. Tall Ironweed. Good Hope Twp., Hocking Co.
2212. *Achillea millefolium* L. Common Milfoil. Fairfield Co.
2239. *Erechites hieracifolia* (L.) Raf. Fireweed. Good Hope Twp., Hocking Co.

BOOK NOTICES

All about Virus Diseases

Anyone wishing to be brought up to date concerning virus diseases should read Seiffert's "Virus Diseases in Man, Animal and Plant." Here can be found a comprehensive survey of present day knowledge of the subject. The book is composed of six divisions. In the first division general concepts of vira and their behavior are discussed. The second and largest division takes up 182 pages, in which 78 virus diseases in man, animals and plants are discussed. One division is concerned with virus-like organisms and another with filtrable types of bacteria. One division takes up the various methods of virus investigation. The final section is a reference index.—*D. C. Rife.*

Virus Diseases in Man, Animal and Plant. Gustav Seiffert. VI Divisions, 332 pp. The Philosophical Library, New York. 1944.

Genes and the Man

"Genes and the Man" may more appropriately be thought of as an elementary text book of human biology than as one of genetics. While genetic principles are stressed throughout, much of the book has to do with embryology and physiology. There are six chapters, which vary considerably in length. Chapter V, entitled "From Potentialities to Realization," is the longest, covering 128 pages, and is almost entirely devoted to human embryology. The shortest chapter, "On Growing Old," is only 23 pages in length, and, as one might surmise, deals with longevity. One chapter deals exclusively with sex, giving a discussion of the evolution of sexuality, as well as sex determination and sex-linked factors. The book contains a wealth of material and is well illustrated. "Genes and the Man" should make a good text for serious minded college students who take only one course dealing with human biology.—*D. C. Rife.*

Genes and the Man. Bentley Glass. VI Chapters, 386 pp. Columbia University Press. 1943.

Alaska Diary

The late Ales Hrdlicka, one of the most widely known anthropologists in America, was Curator of Physical Anthropology at the United States National Museum for thirty-three years. In 1926 he decided to go to Alaska in search of evidence which would throw light upon the entry of man into the New World from Asia across Bering Strait. *Alaska Diary* consists of the daily record of this journey along with the day by day accounts of his three following expeditions made in 1929, 1930 and 1931.

Traveling by boat, the author explored the lower portions of the Yukon River, the Kuskokwim River, and the Nushagak River. The diary, which makes no pretense to literary style, deals largely with details of traveling through a poorly settled country and with the minor hardships encountered on the trips. He stopped at "old" and "new" village sites of both the Indians and Eskimos. At the modern villages he would measure the adults and give free medical treatment to those who were ailing and at the old and abandoned sites he would collect human skeletons and artifacts. He soon became known to the natives along the rivers as the "skull doctor" and in the main was well received by them. Mosquitoes and other biting insects, along with barking dogs, made it hard to get enough sleep but the author showed remarkable endurance for a man of his age.

Alaska Diary does not make smooth reading and if one is looking for information pertaining to the "customs, traditions and characteristics" of the natives of the region he will be disappointed. Physical anthropologists and archaeologists probably will question the value of some of the material for scientific purposes but it must pe kept in mind that this was a pioneering work. Its greatest value may well prove to be the information it contains concerning the locations of archaeological sites. Many sites were untouched by Hrdlicka due to lack of time, lack of assistance, and the frozen condition of the ground. The future archaeologist working in the area will have much of the reconnaissance work already done for him and can excavate some of the more important sites without further search.

The illustrations showing Indian and Eskimo types and scenes along the rivers add considerably to the book's interest even though they are not so good from the technical standpoint. Those interested in the scientific aspects of the expeditions may consult the various reports which are mentioned at the end of the book. *Alaska Diary* will be of interest to anyone planning to travel in Alaska or to the reader who likes to travel vicariously.—*Richard G. Morgan.*

Alaska Diary, by Ales Hrdlicka, The Jacques Cattell Press, Lancaster, Pennsylvania. 1943. xv—414 pp., 232 Illus., $5.00.